# ...NDS AND DITCHES

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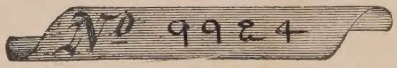


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FLOSCULARIA.

NATURAL HISTORY RAMBLES.

# PONDS AND DITCHES.

BY

M. C. COOKE, M.A., LL.D.

AUTHOR OF "THE WOODLANDS," ETC., ETC.

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# PONDS AND DITCHES.

## CHAPTER I.

### STILL WATERS.

In the present series of volumes, "Lakes and Rivers' have already been provided for, which may be interpreted as including all fresh-waters having a current, but exclusive of standing pools and stagnant ditches. This at first sight might appear to be a distinction without a difference, but we hope to make it appear that there is a very considerable difference between the two. The volume just alluded to includes the valleys through which the streams pursue their course, the plants which inhabit the low marshy land on each side the channel, the animals and birds that are peculiar to low-lying districts, and, above all, the fishes which swim in the fresh waters, and the insects which live and die upon their banks. All these belong especially to rivers and lakes with their surroundings; but it will at once become evident to the naturalist that there remains a large aquatic region, with its own fauna and flora, untouched by books limited to the sea on the one hand, and to running waters on the other. The few plants which are to

be found in streams are not the same as those which choke up stagnant ditches, or flourish in profusion in ponds, in many of which fishes would disdain to dwell.

Definitions are unsatisfactory generalizations in the majority of instances, to which this is hardly an exception. It is not easy to define in a few words the area over which our wanderings are intended to extend; this will become more evident from a perusal of the whole work. It may be premised, however, that in commons, marshes, and low districts, there are miles after miles of ditches which have no perceptible current, only varying in height, not with the tides, but only with wet or dry seasons; ditches in which vegetation appears to run wild, three-fourths of the surface being covered with the leaves of aquatic plants, or a green scum, and whose dark waters, impregnated with the decay of plants, have sometimes an unmistakable odour. Such ditches swarm with living creatures too numerous for more than a small portion to come under our notice. Then again there are more recent openings, "turbaries," straight cuttings made in marshy land by digging out the turf or peat for fuel. In some counties the mileage of such cuttings is by no means insignificant. May we not also to a considerable extent include canals within the terms of our definition? certainly it will be conceded that ornamental waters cut out to adorn a park, or add to the prospect of a mansion, come within the scope of still waters. Add to these also ponds and reservoirs, fish-ponds, duck-ponds, horse-ponds, ponds upon commons, moors, heaths, or be-

side the village green. Wherever there is an expanse of water, not even larger than could be covered with a blanket, or a ditch no wider than can be straddled over, if there is no perceptible flow or current, then we claim for it the definition of "still waters," and extend over it our jurisdiction. It is not by any means the largest pond or the widest ditch that yields the most interesting objects, for a little puddle on a common, scarcely more than a yard square, may be a prolific hunting ground; and if we bear in mind that we are rambling beside *still* waters, the limits of our domain will be sufficiently indicated.

If we confine ourselves absolutely to aquatic plants and animals, excluding all the vegetation of the banks, all the birds of the air, all the fishes that swim, it may be urged that very little is left to us, either to give interest to a volume, or a ramble, except very *little* creatures, and very insignificant plants. This may be true, but size is no attribute of beauty, and the smallest and meanest creature that crawls may teach us something. In all the volumes contained in this series hitherto, the objects have at any rate been visible to the naked eye; amongst the animal world, very few have been smaller than the house-fly, and yet this insect occupies, for size, about the middle place in creation. It has been calculated that between the elephant, as representing the largest animal known, on the one hand, and the most minute living creature yet discovered on the other, the middle position, as regards bulk, between the largest and the smallest, would be that of an insect the size of

the common house-fly. Surely we know only half creation if we ignore all beneath this limit, and it shall be our excuse that, in defence of half the world, this book is written.

At once it becomes our duty to confess that, although we shall endeavour not to write of animals smaller than can be seen with an ordinary pocket-lens, it is our intention to introduce our readers to a number of very minute organized beings, creatures whose whole world is a little puddle of water, who are born, and die, and leave behind them a progeny like themselves, and yet their place in creation may be represented by the punctuation point at the end of this sentence.

What said Charles Kingsley?—"The zoophytes and microscopic animalcules which people every shore, and every drop of water, have been now raised to a rank in the human mind more important, perhaps, than even those gigantic monsters, whose models fill the lake at the Crystal Palace. The research which has been bestowed for the last century upon these once-unnoticed atomies has well repaid itself; for from no branch of physical science has more been learnt of the *scientia scientiarum*, the priceless art of learning; no branch of science has more utterly confounded the wisdom of the wise, shattered to pieces systems and theories, and the idolatry of arbitrary names, and taught men to be silent while his Maker speaks, than this apparent pedantry of zoophytology, in which our old distinctions of 'animal,' 'vegetable,' and 'mineral,' are trembling in the balance, seemingly ready to vanish like their fellows

—'the four elements' of fire, earth, air, and water. No branch of science has helped so much to sweep away that sensuous idolatry of mere size, which tempts man to admire and respect objects in proportion to the number of feet or inches which they occupy in space. No branch of science, moreover, has been more humbling to the boasted rapidity and omnipotence of the human reason, or has more taught those who have eyes to see, and hearts to understand, how weak and wayward, staggering and slow, are the steps of our fallen race (rapid and triumphant enough in that broad road of theories which leads to intellectual destruction), whensoever they tread the narrow path of true science, which leads (if I may be allowed to transfer our Lord's great parable from moral to intellectual matters) to life; to the living and permanent knowledge of living things, and of the laws of their existence."[1]

At once, then, let us make bold and candid confession that henceforth our interest in a fellow-inhabitant of God's world is not a question of inches, or parts of an inch, and that magnitude is no criterion of admission into our investigations.

There should be no misconception as to the necessities of rambles of such a description. Those who go abroad in search of absolutely microscopical objects do not carry a microscope with them, and our ramblers need not be provided with any other help for their eyes than a pocket-lens of an inch focus, carried in the waistcoat-pocket. This will be all that

[1] "Glaucus, or Wonders of the Shore," p. 33.

is needed for the work at the pond, but the examination and investigation of all the beauties which these organisms exhibit, implies afterwards the use of the microscope. Yet, even without the microscope, how much may be learnt, what interest may be excited? A bottle of water-fleas, held up to the light, may afford considerable pleasure; their jerky movements, their vivacity, and their mode of life may be seen and watched even with the unaided eye; but to count their legs, to see the movements going on within their transparent bodies, will require other help.

This is not a plea on behalf of the minute organisms alone, it applies equally to larger animals and plants. The curious structure of bat's hair, a bird's feather, a butterfly's wing, the florets of a daisy, the sting of a nettle, are all hidden from the naked eye, and no one can claim the title of naturalist who ignores the use of the microscope. In our closing chapter, we propose giving such hints as may be necessary to follow up the investigations to which the chapters which precede it are only an intro duction.

There is little need for apology on behalf of a volume which comes into existence without a competitor. The nearest approach dates from twenty years ago, but even this made no attempt to cover more than a portion of the ground which we have essayed. In an age of books it is strange that the rambler beside ponds and ditches should have been left without a pocket-companion. And now that we venture to believe in the existence of some who desire such counsel, we cannot but link it with a faith

in the ultimate satisfaction which follows from a persistent endeavour to search out the unseen works of the Creator. The pursuit of such studies, in their lowest results, is a good school for the exercise of patience and perseverance, and in their highest, it brings one into contact with the manifestations of Divine power, as exhibited in a world hidden from the uninquiring eye, but withal as wonderful, if not even more astonishing, than that in which we live, and move, and which we contemplate with unaided sight. The student who brings with him a desire to see the Maker revealed in His works, will never repent having wandered over an untrodden field.

Some of the attributes of the student of Nature are admirably portrayed by an author already quoted, and may fitly close this introduction :—"He should be brave and enterprising, and withal patient and undaunted; not merely in travel, but in investigation; knowing (as Lord Bacon might have put it), that the kingdom of Nature, like the kingdom of Heaven, must be taken by violence, and that only to those who knock long and earnestly does the great mother open the doors of her sanctuary. He must be of a reverent turn of mind also, not rashly discrediting any reports, however vague and fragmentary, giving man credit always for some germ of worth, and giving Nature credit for an inexhaustible fertility and variety, which will keep him his life long always reverent, yet never superstitious; wondering at the commonest, but not surprised by the most strange; free from the idols of size and sensuous loveliness; able to see grandeur in the minutest objects, beauty

in the most ungainly; estimating each thing, not carnally as the vulgar do, by its size, or its pleasantness to the senses, but spiritually by the amount of Divine thought revealed to him therein; holding every phenomenon worth the noting down; believing that every pebble holds a treasure, every bud a revelation; making it a point of conscience to pass over nothing through laziness, or hastiness, lest the vision, once offered and despised, should be withdrawn; and looking at every object as if he were never to behold it again."[1]

[1] Kingsley's "Glaucus," p. 46.

## CHAPTER II.

### FLOWERING PLANTS.

THOSE who expect to find in marshes and swampy places the same flowers and plants as are familiar to them in lanes and woodlands, will be very much disappointed. There is such a marked distinction between the character of the plants found growing in low swampy places, marshes, and bogs, and those habitual to pastures, woods, and hedge-rows, that the young botanist will find himself in presence of as distinct a flora as if he were to travel to some foreign country. So many of the usual inhabitants of such localities are enumerated in a companion volume to the present,[1] that it is our intention to allude only to those which are thoroughly aquatic in their habits, that is to say, to plants which will be found growing *in* the water of ponds and ditches, rather than to those which flourish only on their margins. Rivers and running streams are very deficient in growing plants, except along their borders, whilst stagnant waters teem with growing plants of various kinds, large and small, many being so very minute as to be almost, or quite, invisible to the naked eye. Flowering-plants, or those which produce conspicuous

[1] "Lakes and Rivers."

flowers, are always large enough to be seen. What an inexhaustible store for investigation will be presented by a single stagnant ditch, choked with vegetation, such as Norfolk, Cambridgeshire, and Lincolnshire could furnish.

Almost the first plant which would attract notice

WATER CROWFOOT.

in ponds and some ditches would be the little white

flowers of the Water Crowfoot,[1] just peering above the surface of the water. The leaves are submerged and very variable, the upper ones being three-lobed, but the lower ones almost skeletons. The great variability of this plant has led some botanists to regard many of the forms as distinct species, but this need not trouble us, who are content to regard them all as simply the Water Crowfoot. This plant is so common that it should be at once recognized; indeed, it is essential that all the ordinary flowering-plants which grow in ditches should be readily distinguished, on account of the large number of minute animals which will be found adhering to them, so that hereafter we shall constantly have to refer to the names of plants which we are now about briefly to describe.

Still more imposing in appearance are the White[2] and Yellow Water Lily,[3] their large, smooth, glossy leaves lying on the surface of the water. It has been asserted that the flowers of the latter have the odour of brandy, and hence in Norfolk are called "Brandy-bottle." As far as our experience of Norfolk goes, it is the flask-shaped seed vessels which are called "Brandy-bottles," from their resemblance to a flask. The water-lilies are the noblest of British aquatic plants, and the under surface of the broad-spreading leaves afford shelter and a home for many a minute animal. The sacred Lotus of Egypt and India was a water-lily, and its flowers were largely employed in the sculptures which decorated their

[1] *Ranunculus aquatilis.* [2] *Nymphæa alba.*
[3] *Nuphar lutea.*

temples. The Water Villarsia[1] is too uncommon a plant to cause much trouble in its identification. It has somewhat the habit of a small water-lily.

YELLOW WATER-LILY.

There are two very prominent plants in ditches from their tall erect straggling mode of flowering.

[1] *Villarsia nymphœoides.*

One of these is the great Water Plantain,[1] with long lance-shaped leaves, standing erect on long stalks,

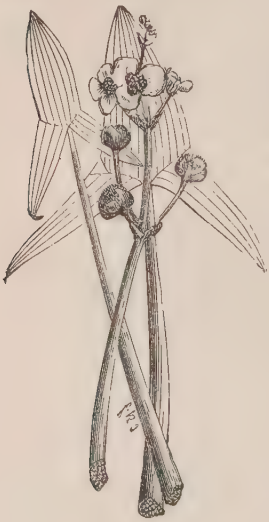
WATER PLANTAIN.

the veins of the leaf running parallel, as in the Common Plantain. The flowering stem is at least 2 ft.

[1] *Alisma plantago.*

above the surface of the water, with many long slender branches, and numerous three-petalled flowers, which are so delicate that they soon fall away. During the winter the naked flower-stalks remain standing like skeleton sentinels in the silent water.

The other plant is most remarkable for the shape of its leaves. It is the Arrow-Head[1] with its arrow-shaped leaves standing erect out of the water on long foot-stalks, covering at times a very large surface, either alone, or mingled with the Water Plantain. The three-petalled flowers are rather inconspicuous, but the leaves are so characteristic that they are quite sufficient for the identification of the plant. Perhaps there are no more common plants than these two in stagnant ditches; both possess farinaceous roots, and those of the Arrow-Head have been used as food in times of scarcity, whilst the Chinese obtain a meal from them which is commonly eaten.



ARROW-HEAD.

One of the most beautiful of ditch plants is that called the Flowering Rush,[2] but it is by no means common.

[1] *Sagittaria sagittifolia.* [2] *Butomus umbellatus.*

Here we may notice a very insignificant little plant, as far as size and appearance is concerned, but most remarkable for its rapidity of increase. This is sometimes called the American Water-Weed,[1] because it was introduced from that country. It is believed to have come over with some timber, and thus got transplanted into the canal near Market Harborough about the year 1847, and from thence spread over England. Five years previous to this it was found in a pond in Berwickshire, from whence it probably made its way in Scotland. The plant grows entirely in the water in dense masses, with a thin brittle stem, around which the leaves, about half-an-inch long, grow in threes or fours. As only the female plant is known in this country, its entire diffusion has been by joints, or portions broken off, and not by seeds. In 1851 the plant was noticed in the river between Ely and Cambridge, since which time it has increased so rapidly that it has become the greatest source of annoy-

AMERICAN WATER-WEED.

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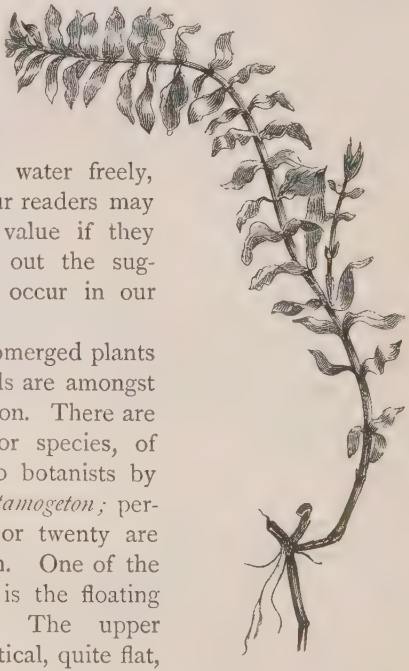
[1] *Anacharis alsinastrum.*

ance to watermen, and navigation seems almost to be arrested by it. The railway dock at Ely became so choked with it that several tons had to be lifted out. It is difficult to say where in the three kingdoms it may not now be found. With its serious faults, it has also one small feature of utility, since it is one of the best plants for cultivation in a small fresh-water aquarium, where it grows rapidly, oxygenates the water freely, and some of our readers may experience its value if they desire to carry out the suggestions which occur in our volume.



POND-WEED.

Of totally submerged plants the Pond-Weeds are amongst the most common. There are several kinds, or species, of them known to botanists by the name of *Potamogeton;* perhaps eighteen or twenty are found in Britain. One of the most common is the floating Pond-Weed.[1] The upper leaves are elliptical, quite flat, on very long slender stalks,

[1] *Potamogeton natans.*

and lie on the surface of the water, as though they had no plant to belong to. The small green flowers are produced on a spike which rises above the surface of the water. There are other species with long, narrow, grass-like leaves, and others again with leaves almost as narrow as threads. The Pond-Weed with opposite leaves,[1] has the thin, almost transparent, green leaves arranged in pairs along a slender flexuous stem. When the leaves of some of these weeds are dried they are almost as thin and delicate as gold-beater's skin. The flowers are without any attraction, either of colour or odour, and the plants would scarcely deserve mention did they not serve as food or shelter to so many aquatic animals. Entirely covered as are many of them by the water in which they flourish, they are seldom seen except when dredged up from their homes by the botanist, or by the workmen in cleansing the ditches. Either a walking-stick with a hook or small rake at the end, or, better still, a few yards of cord with a small iron hook with three prongs attached, will serve to bring these and other water-weeds to the shore. With such an instrument as this, which can be thrown some few yards into the middle of a pond, sinking by its own weight, will bring the water-lily leaves, pond-weeds, and other plants within range of observation, otherwise they will remain out of reach, greatly to the annoyance of the poor wanderer who stands upon the brink and wonders what may be the treasures which he sees but cannot touch.

[1] *Potamogeton densum.*

The same means which brings the pond-weeds to the shore will doubtless bring with them also the following three allied plants, or one of them. The Mare's-tail,[1] which, by-the-by, is quite different from the Horse-tails, allied to ferns, and not aquatic plants. The Common Mare's-tail has jointed stems, around which the narrow thready leaves grow in whorls or circles, radiating like a star. The Water Milfoil,[2] which has leaves deeply cut into narrow thready segments and slender branched stems intertwined in a tangled mass when drawn out of the water, in which it grows wholly submerged. The Hornwort[3] has narrow leaves surrounding the stem in whorls or circles, but these differ from those of the mare's-tail in being divided two or three times in a forked manner, forming a more dense mass of foliage. Any of these three plants may be found in still waters.

MARE'S-TAIL.

A slender little plant not uncommon in ditches is the Starwort,[4] so called because the little pale-green leaves are arranged like a star or rosette, at the top

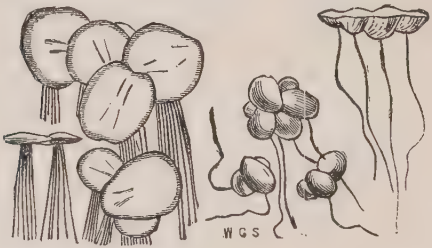
[1] *Hippuris vulgaris.*
[2] *Myriophyllum spicatum.*
[3] *Ceratophyllum demersum.*
[4] *Callitriche verna.*

of the slender stem, and this rosette floats on the surface whilst the submerged stem has the leaves in pairs, and long thready roots springing from the joints. The plant is but slightly attached to the ground, so that it may be lifted out of the water without any perceptible resistance. It may be seen growing in company with duckweed, or by itself in stagnant pools, sometimes in running water.

HORNWORT.

This reminds us of the Duckweeds. Of course every one knows "duckweed," and yet very few know much about them. They are very small, insignificant plants, and yet they possess considerable interest, for small as they are they possess flowers. We see them floating together by hundreds and thousands on the surface of still water, like so many little leaves, and we call them "duckweed," and think no more about them. There are four species of duckweed found in

Britain, and the differences between them it may be as well to state at once. The Greater Duckweed[1] has the fronds, or little green plates resembling a




GREATER DUCKWEED AND THICK DUCKWEED.

small leaf, larger than any other species, nearly circular, rather thick, with a cluster of fibres, like roots, proceeding from the under-surface. The Lesser Duckweed[2] is the most common; it has small ovate fronds, generally two or three adhering together, with one root-fibre proceeding from the under-side of each. The Thick Duckweed[3] has fronds of nearly the same shape and size as the last, but thicker, flattened above, and rounded beneath, each with a single root filament. It grows in the most stagnant and fetid waters, and is supposed to be uncommon, though some there are who think it is only a variety of the Lesser Duckweed. Lastly, there is the Ivy-leaved Duckweed;[4] the fronds are nearly half an inch long, thinner than in the other species, narrowed

[1] *Lemna polyrhiza.*
[2] *Lemna minor.*
[3] *Lemna gibba.*
[4] *Lemna trisulca.*

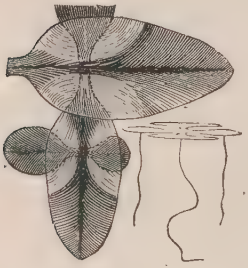
towards each end, with a single root filament to each frond. These are all floating plants; that is, they are in no way attached to a single spot as most plants,

IVY-LEAVED DUCKWEED AND LESSER DUCKWEED.

but float freely on the surface of the water. There are no stems, and no real leaves, but the whole plant consists of a small frond, which resembles a leaf in appearance, and one or more little threads proceeding from the under-surface, hang down in the water and perform the functions of a root, but they do not become attached to anything. The fronds are sometimes separate, and sometimes two or three adhere together. They increase and multiply by young ones budding out at the sides, or rather the edges of the full-grown frond. The flowers are very small and rare, but when produced they grow out of little cracks or fissures at the edge of the fronds.

A very good plan to adopt for the study of these curious little plants is to collect them with the water in which they are found, in a wide-mouthed bottle, and when safely carried home transferred to an ordinary tumbler-glass, in which they will keep alive and

grow for some time, so that they may be seen budding and increasing, and flourishing as well as in their native ditches.[1] A little plant, called Wolffia,[2] has been recognised in this country only in recent years. It looks very like a small duckweed, and grows in similar situations, but it will be recognised from them by the fact of its having no rootlet proceeding from the under-surface of the frond.



DUCKWEED, SHOWING MODE OF GROWTH.

Thus far the plants which we have enumerated are chiefly confined to still water, and many of them are entirely aquatic. There are, however, some others which must be mentioned in order to render our catalogue at all complete, which are not confined exclusively to ponds and ditches, but are commonly found there.

The most important of these additional plants is the Common Reed,[3] which is seldom absent from still waters or sluggish streams, growing under favourable conditions to a considerable height, and often extending for many acres, forming large "reed beds" in fenny districts, as in Norfolk and Lincolnshire. Those large expanses of water known to Norfolk people as the "broads" are spots which ever live in

[1] "Science-Gossip," January 1st, 1865. [2] *Wolffia arrhiza.*
[3] *Phragmites communis.*

the memory of the naturalist who has frequented them. Here the reeds and their inhabitants may be seen in their best aspect. One who knows them well

COMMON REED.

has thus written in their praise. The lavish notes of the Reed Warbler "are thus associated in my mind

with many a calm summer's night on the open broads, the stars shining brightly overhead, and the soft breeze sighing through the rustling reeds, mingled with the hum of insect life on the water. It is at such times that the song of these marsh nightingales is heard to perfection. All is still around, save those murmuring sounds that seem to lull to sleep ; the barking of the watch-dog has ceased in the distance, and the hoarse croak of the coot or the moorhen, harmonizes too well with the scene to startle with its frequent repetition. Presently, as if by magic, the reed beds on all sides are teeming with melody ; now here, now there, first one, then another, and another of the reed birds pour forth their rich, mocking notes, taken up again and again by others ; and still, far away in the distance, the same strain comes back upon the breeze, till one is lost in wonder at their numbers, so startling to the ear of the stranger, so impossible to be estimated at all during the day. I can imagine few things more delightful to the out-door naturalist than his first introduction to the broads by night. The mere escape for a time during the height of summer from the heat and bustle of a city life might alone repay the trouble of a visit, were there no further attractions in those sights and sounds which have for the naturalist a peculiar charm." And thus he concludes :—" Wrapt in the enjoyment of these rural sounds, one glides gently down the stream towards the entrance of the broad , the soft breeze rustles amongst the feathery reed-tops and the light foliage of the willows by the river side, the wide expanse of water glows with the reflection of the setting sun, whilst the rippling waves

upon its surface dance and sparkle on their way, as though hastening onward to those quiet shades where twilight, stealing over the landscape, speaks of sleep and rest for the weary."[1]

But reeds are not the only grasses that love the water, there are, at least, two others which should be mentioned as especially aquatic. The Flote-grass,[2] with its long leaves floating on the surface of the water, and its long slender panicle bending and waving above them. The small seeds of this species, it is said, were collected and used by the Russians as food, under the name of "Manna-croup," although the modern manna-croup of commerce is only an imitation of the rarer commodity. Another species of the same genus,[3] with erect panicles, grows in similar places. One or other may often be seen growing near the margin of a pond.

FLOTE-GRASS.

[1] Stevenson's "Birds of Norfolk," i. p. 118.

[2] *Glyceria fluitans.* [3] *Glyceria aquatica.*

CATABROSA.

The Water Whorl-grass[1] has a much more spreading panicle than either of the foregoing, and is a noble grass when growing in perfection, but it

[1] *Catabrosa aquatica.*

shares the fate of all grasses with the young botanist, that of being thrust aside as "only a grass;" and even many of those who are no longer young will not take the trouble necessary to understand the grasses.

Ponds with a muddy bottom will contain also the "Black-weed"[1] or "Bur-reed," of which there are two species, differing chiefly in the flowering stem being either branched or simple. The leaves are long and sword-shaped, and the flowers (afterwards also the fruit) are collected in globose heads. We have generally observed that the presence of this plant indicates a black, oozy mud at the bottom, in which it grows. Old anglers in the "broads" who loved the reeds always shunned the neighbourhood of the "Black-weed," as it was called, because it flourished in a black, stinking mud, which even fishes did not approve.

The Reed-mace, or Cat's-tail, is of two kinds, principally to be distinguished by their size, and hence called the Greater Reed-mace[2] and the Lesser Reed-mace.[3] They will reach a height of six feet, and are conspicuous from a distance by the dark, club-like spike, which grows at the end of the straight cylindrical flowering stem. This club is at first a dense mass of the female flowers, the male flowers being yellow, and growing above them. Finally, the whole of the spike contains seeds with a downy crest which aids in their dispersion. When fully ripe, if

[1] *Sparganium ramosum* and *S. simplex.* [2] *Typha latifolia.*
[3] *Typha angustifolia.*

REED-MACE.

one of these clubs is broken, it soon becomes converted into a light puffy down by the expansion of the crests, and in this state the cottagers use it as a stuffing for pillows. It is a curious fact, that both in New Zealand and Northern India the pollen of either this, or a very nearly allied species, is collected by the natives and made into cakes and eaten.

The Bulrush[1] is often found in company with the Reed-mace. It is like a gigantic rush, as thick as the little finger, and nearly six feet high. Large quantities are grown in marshy districts, in shallow water, and are cut in the autumn, by men in flat-bottomed boats, dried and manufactured into matting, baskets,

[1] *Scirpus lacustris.*

horse-collars, and other articles, so that in some villages it is an important branch of industry. The bulrush of Scripture is not this plant, and must not be confounded with it. The bulrush of the Egyptians is said by some authors to have been the papyrus, which was employed for writing upon, after the manner of paper. This could hardly have been the case. The right of growing and selling the papyrus belonged to the Government, it was a monopoly, and the plants were rooted up in all places except those under Government supervision. The monopoly so increased the price that persons in humble life could not afford to purchase the papyrus for writing purposes. When Pliny says that the papyrus had many uses, and that the Egyptians even "constructed small boats of the plant," he probably confounded some similar plant of inferior value with the hieratic papyrus. It is probable that, as Sir Gardner Wilkinson has suggested, boats were made of rushes, bound together with papyrus, or the fibrous portion of the papyrus, rendered impervious to water by a coating of pitch. It is of little consequence what particular kind of rush was employed, whether or not it was that superior kind which was a monopoly of the Government, and used for writing, or a commoner kind of rush; there is no doubt that boats were made of rushes in Egypt, and that they were coated with bitumen, or some other substance, which rendered them impervious to water.

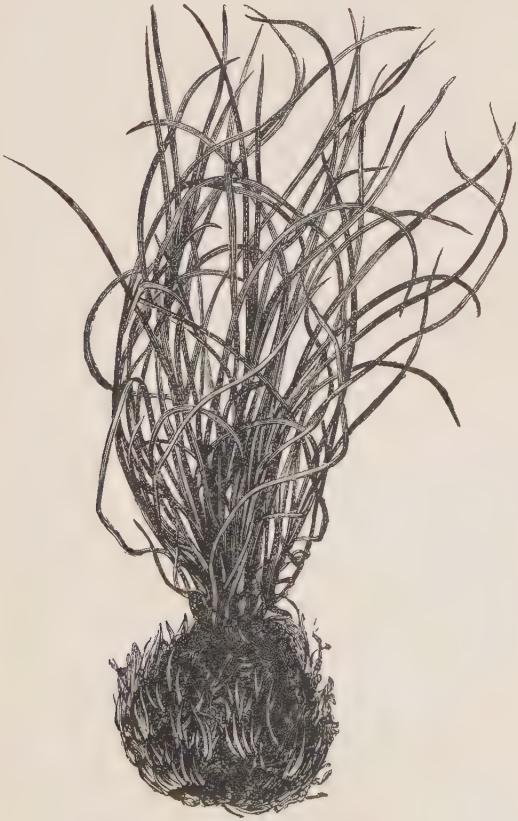
## CHAPTER III.

### PLANTS WITHOUT FLOWERS.

For the sake of convenience we associated together in the previous chapter all plants bearing evident or conspicuous flowers, such being usually termed "Flowering Plants." There remain, however, a few which occur in our localities, belonging to what botanists term the "higher cryptogams:" plants which do not bear conspicuous flowers, but are reproduced by means of organs, in which some only of the characteristics of perfect flowers are present. The limits and distinctions of these groups will be found in any good botanical manual.

The number of plants with aquatic habits which belong to the intermediate families between flowering plants and Algæ is small, but they could not be omitted altogether, as they are some of them found in no other situations, and hence would be excluded wholly from these volumes. It forms no portion of our creed that sound information on scientific subjects cannot be communicated except in strict scientific sequence and in true systematic order. Nevertheless, where and when a general adherence to definite groups is a manifest advantage both to author and reader, it would be folly to relinquish the advantage. In the present instance, the division adopted serves

to associate together kindred plants, and facilitate reference to them when the plan of grouping is comprehended.



QUILL-WORT (*Isoëtes hystrix*).

Ferns are not aquatic; although the Royal Fern is so nearly a plant of that character that it flourishes best in swampy places, and is often planted as an aquatic in artificial waters. Of plants kindred to the ferns the Little Quill-wort [1] is often to be seen covering the bottom of lakes over a very considerable area, but confined to mountainous districts. The horny leaves have to the eye an appearance similar to some grasses in form, but far different in texture, growing erect in small tufts with the fruit, about the size of a pea, hidden under the bulging bases of the leaves. One or more species flourish so plentifully in the lakes of Cashmere that the seeds float like a scum on the surface, and are collected by the natives and employed in medicine.

The Pillwort,[2] or Pepper-grass, is not so completely immersed, but prefers the margins of lakes and pools, in tolerable plenty in some places, but, like the quill-wort, it is local. The stolons, or creeping stems, extend for a considerable distance, sending up here and there small tufts of slender, grasslike leaves. The capsules are about as large as a peppercorn, and grow in the axils of the leaves upon the stolons. These are both curious plants, and on account of their habits are known to few except botanists.

Some of the Horse-tails are often to be seen growing in the water of ditches, but they are not so truly aquatic as the plants to which we have confined our observations. The Greater Horse-tail is the most water-loving species, and furnishes an interesting

[1] *Isoëtes lacustris*, and *Isoëtes hystrix*. [2] *Pilularia globulifera*.

object for study, not only in its ribbed flinty stems, but also in its spores, and the manner in which they are produced.

Far more delicate plants, always wholly submerged, and very different in appearance, have been regarded by some as nearest of kin to the Horse-tails. By others they are associated with the Algæ. Sometimes included in one group, and sometimes in another, it will be conceded that there must be some reason for this uncertainty, and that this reason is associated with important features in the structure of the plants themselves. This is indeed the fact, for the plants alluded to grow submerged like Algæ, with brittle joints, slender branches, and no leaves, like the Horse-tails, without true flowers, but with substitutes for flowers, unlike those of any other known plants.

In clear ditches with a muddy bottom these plants may be seen growing to the height of a foot, in clusters as much in diameter, composed of threadlike stems very much branched, with equally threadlike branchlets growing in whorls or circles around the stem. In lifting them from the water some are so fragile that they have a tendency to break up into joints; all are delicate, and require careful handling.

These plants are known to botanists as the *Characeæ;* they have no true flowers, and yet they much resemble some flowering plants, whilst the curious fruit grows at the base of the tufts of leaflike branchlets, unlike that of the Algæ. They are a sort of outside group, which do not harmonize with any other, so that they are kept by themselves, and only known as the Characeæ.

We have spoken of the leaves as surrounding the slender stems in circles, but this is no accurate term as applied to these plants, for they are *not* leaves, but branches, which are themselves again branched or sub-divided. The Characeæ have no veritable leaves, although the ultimate branches very much resemble leaves, and perform the same functions. There are two kinds, or genera, of these plants ; in one, called *Nitella*, the stem is a single-jointed tube ; the other, called *Chara*, has a central tube, and smaller ones arranged around it. One has, therefore, a simple stem, and the other a compound one.

It may be remarked here that, some years ago, we gathered one of these plants entire from its native ditch, with the roots attached and a little adhering mud. It was taken home and planted in an inverted propagating glass, about twelve inches in diameter, some small pebbles covered over the roots and around the bottom, so as to keep it in position, and the glass filled with ordinary "supply" water. It soon became established, grew vigorously until the whole glass was filled, produced its singular fruits, and continued to thrive for upwards of three years, until the glass was accidentally broken, and it came to an untimely end. During the whole of this time the water was perfectly clear and fresh, although it was never changed or aërated. Additions were made to compensate for evaporation, but it was a perfect aquarium, not requiring the least attention, and the stagnant water was kept thoroughly pure by the action of the plant itself. We have tried other plants and combinations of plants for like purposes, but this is the only

NITELLA.

instance in which the purity of the water was maintained.

Of Chara and Nitella there are about sixteen British species, some of which are scarce and others common, but their minute distinctions and differences would scarcely interest our readers. They will readily be recognised, growing in perfectly clear and motionless ditches, by their pale green colour and threadlike ramifications. To remove them entire will require care. Some weapon, such as a hooked stick, passed round the roots so as to remove them from the mud, then drawn carefully to the shore and lifted out, keeping the roots foremost, and all the branches hanging towards the crown, will usually prove successful. An established plant will constitute a good aquarium in which the minute aquatic animals may be kept under constant observation.

Mosses are scarcely aquatic, although some species love to grow beneath the spray of waterfalls, on moist dripping rocks, and in some instances, as in that of *Fontinalis*, wholly submerged in rapid streams.[1] The Bog-mosses[2] are an exception not only to mosses, in the nature of their fructification, but to the generality of them in their habits. They delight in bogs and swamps. Elevated moors abound with them, and some common forms are found in every swamp.

The Bog-mosses having received no attention in other volumes of this series, we may be excused for

[1] Certain species of *Hypnum* are great lovers of water, as *H. fluitans*, *fluviatile*, *irriguum*, &c.

[2] *Sphagnum*.

regarding them as pond-plants, and bringing them under our own jurisdiction. As they are now treated as distinct from the true mosses by the bryologists, we may assume that there are good reasons for doing so, and proceed with them without drawing comparisons. They are large, pale-coloured, erect plants, sometimes a foot long, usually less, growing closely packed side by side in dense masses, often many yards in extent, in swamps, the lower portion in clear, still water, which, however, must be comparatively pure. A handful taken out from such a mass is found to be saturated with water like a sponge. Place your foot on such a treacherous spot, and down it goes amongst water and mud, with no firm bottom to be found. Separate one plant from the rest, and note the thin, tough wiry stem, the short branches spreading in all directions, more compact above, until the summit is crowned by an elegant rosette. The branches are entirely covered with scalelike, imbricated leaves. When in fruit, the little oval capsule stands erect on its peduncle, which

SQUARROSE BOG-MOSS.

springs from one of the uppermost branches. This is the general appearance of one of the bog-mosses.

It would scarcely come within our province to enter fully upon the structure, development, and reproduction of these organisms; nor is this so much to be regretted, since Dr. R. Braithwaite (than whom no one is more competent for the work) has elsewhere most clearly and thoroughly exhausted the subject,[1] and described fully all the European species.

Those who possess a microscope will find in the leaves a very pretty study. The cellular network forming sigmoid areolæ, and the delicate spiral or ringlike fibre of the cells, with the intercellular ducts, containing a coloured endochrome. Nor will the spores be without interest, for they are of two kinds, the large tetrahedral macrospores, and the smaller globose microspores. Sometimes the spores will germinate in the capsule when placed in favourable conditions. The spores which germinate in the water develop in a different manner to those which germinate upon damp earth. Under the latter condition they will germinate in from two to three months.

And what are the uses of these bog-mosses, or, as the Germans call them, "Turf-mosses?" To this Professor Schimper answers, "Unless there were bog-mosses, many a bare mountain ridge, many a high valley of the temperate zone, and large tracts of the northern plains, would present an uniform watery flat, instead of a covering of flowering plants or

[1] "Monthly Microscopical Journal," vols. vi. to xiv.

shady woods. For just as the sphagna suck up the atmospheric moisture and convey it to the earth, do they also contribute to it by pumping up to the surface of the tufts formed by them the standing water which was their cradle, diminish it by promoting evaporation; and, finally, also, by their own detritus, and by that of the numerous other bog-plants to which they serve as a support, remove it entirely, and thus bring about their own destruction. Then, as soon as the plant detritus formed in this manner has elevated itself above the surface water, it is familiar to us by the name of turf, becomes material for fuel, and all sphagnum vegetation ceases."

These are not the only uses of these plants, although those in our minds are infinitely smaller in their relationship to the great scheme of nature than the reclamation of waste or the manufacture of peat. Yet we cannot forget how much the naturalist is, in his way, indebted to the masses of sphagnum which shelter so many minute organisms. The bryologist confesses to the presence of infusoria within the cells of the leaves, but who can enumerate the creatures which sport outside, the water-fleas, the wheel-bearers, and small snails; the confervoid algæ, which adhere sometimes in such quantity that the water which drips from a lifted tuft is redolent with minute vegetable as well as animal life.

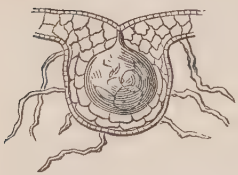
Of the seventeen British species some are rare, others local in their distribution; whilst others again, are common. For us, who do not profess to be critical moss-hunters, the common are as attractive as the rarest; in the ubiquitous blunt-leaved Bog

moss[1] we have all the materials for the study of structure and development, and in that we can read what bog-moss really is, as satisfactorily as in that very rare species (if there be such an one) which is found but once in a hundred years.

There is with us a strong reason why the bog-mosses should be recognised, and that is, that desmids and diatoms are often to be found growing upon them, and hence they will often be alluded to for other reasons than their own individual merits.

The aquatic plants most kindred to the mosses are two species of minute plants found floating on the surface of standing water, mixed with duckweed, but larger, though in some points similar. These belong to what are called the Liverworts, or rather to that section called crystal worts. The half-dozen British species of *Riccia* include only two really aquatic; one of these has fronds from one inch in length,[2] repeatedly forked, so that the divisions form narrow segments, slightly notched at the end, of a yellowish green colour. The sporangium is globose, and protuberant on the under side of the frond. Rootlike threads proceed from the under-side

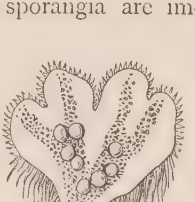
*Riccia fluitans*, nat. size.



*Riccia fluitans*, section of *sporangium*.

[1] *Sphagnum cymbifolium.* [2] *Riccia fluitans.*

of the frond, but these are not attached to anything, as the plant floats freely, mixed with duckweed, on the surface of stagnant pools and ditches. The other species differs from the above in the essential particular that the sporangia are immersed in the frond and not protuberant on either surface beyond a slight indication of their presence.[1] The fronds are about half-an-inch in length, slightly grooved in the centre, inversely heart-shaped, and pale green on the upper surface. The margin and under-surface are clothed with numerous pendent rootlets of a purplish colour. It is sometimes abundant in boggy pools, floating on the surface of the water. Both these will grow readily in pans of water, or on the water of an aquarium, for which purpose they are most desirable objects.



*Riccia natans.*

What are termed by botanists the *Lower Cryptogamia*, consist of Lichens, Fungi, and Algæ. The latter are, of course, well represented in still waters; but the former absent, except in the case of those fungi which are parasitic upon fish, frog-spawn, dead insects, &c., and called the *Saprolegniæ*. Who has not observed dead flies adhering to the window in the autumn, their bodies covered with a frosty white powder, and the same substance adhering to the glass beneath and around them? These poor flies have

[1] *Riccia natans.*

fallen a victim to a parasitic mould,[1] which never advances beyond a very simple condition on the flies in the air, but should the flies fall into the water or be thrown into it, then a much more elaborate developement is given to the mould; fine threads radiate into the water in all directions, and the fly becomes the centre of much such a thready white mass as forms upon fish, and bears the name of "fish mould," or "salmon disease." Not only apparently, but really is it the same kind of thing. That which was a very simple mould, whilst the fly was in the air, developes into one of the Saprolegniæ when the fly gets into the water.[2] Undoubtedly the one mould is only a condition of the other. The fungi differ from these aquatic moulds, especially in not being inhabitants of the waters. We are prepared, therefore, for the Algæ, and with them another chapter.

NOTE.—Consequent upon faulty observation it was at one time believed that the Achlya, which resembles the salmon disease, and is developed upon dead insects in water, was connected genetically with the fly mould. In more recent times it has been demonstrated that there is no connection between them, and that both are wholly independent, and autonomous organisms. Hence the final paragraph of the text was based upon an error, now exploded.

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[1] *Empusa muscæ.* [2] *Achlya prolifera.*

## CHAPTER IV.

### FRESH-WATER ALGÆ.

UNFORTUNATELY we have not in use any word which corresponds to "seaweeds," as applied to similar plants growing in fresh water. Everyone at once will recognise what is intended when the Marine Algæ are called seaweeds, but it is not every one who could comprehend the scope or intentions of such a phrase as "Fresh-water Algæ." Neither would "Confervæ" be sufficiently comprehensive, because so many of the Algæ of fresh waters are by no means Confervæ. The only alternative seems to be the adoption of a word, or phrase, which characterises the plants intended to be included, even though it may not be a phrase in common popular use.

It can hardly have escaped notice that sticks, leaves, rushes, and even stones and rocks, which are immersed in water, soon become covered with tufts of greenish threads, sometimes so minute as to resemble a mere cloudiness of the water, at others forming distinct velvety or long thready tufts. These are some of the fresh-water Algæ, and it is only when magnified that it can be seen what differences there are between them, not only in thickness but also in the arrangement of the green substance, or endochrome, to which the general green appearance is

due. Of course, there are some fresh-water Algæ which float freely and are never attached, but it is more particularly to the tufted, or filamentous kinds, that we would first direct attention, because they are the most conspicuous, and would be the first to be recognised.

Conferva is a very vague term, which has been applied to almost any threadlike filamentous plant found growing in water or damp situations. At one time it included plants of widely diverse character, to which other names have been since applied; but even now it is very usual to call all the threadlike Algæ which grow in fresh water by the general name of Confervæ. They have been very little studied in this country, and the latest book specially devoted to them is nearly forty years old.[1]

The first type which is likely to be met with in exposed pools during summer and autumn is that called *Spirogyra*, in which the filaments are of a bright green colour, and from a fractional part of an inch to nearly a yard in length, composed of cylindrical cells joined end to end. In streams they attach themselves to weeds, and wave in the current like a green fringe, but in quiet pools they usually float on the surface unattached, in green or brown patches. "When viewed under the microscope, with a power of one or two hundred diameters, the bands of chlorophyll, or green colouring matter, are seen disposed in various elegant spirals. In some species

[1] Cooke's "Fresh Water Algæ," in 2 vols., with coloured plates, published since the above was written.

these bands are single, in others there are two, three, or four. Upon these bands, which are generally slightly jagged along their edges, are grains of brighter green, disposed at pretty regular intervals, and adding greatly to the beauty of the plant. Sometimes the larger grains are surrounded with smaller ones, and the bands appear like two festoons of exquisite green flowers."

SPIROGYRA.

The phenomenon of conjugation may be well observed in these Algæ. Two neighbouring threads meet, and throw out from their sides little processes which at length unite, and the cell walls become absorbed, the contents of one cell pass into the other. During this process the spiral coils are relaxed, the symmetrical arrangement of the endochrome is disturbed and lost, and, when the conjugation is complete, the combined contents of the two conjugating cells become an oval spore, from which ultimately a new plant, like its parent, is developed.

*Zygnema* is another group of very similar plants found growing in like situations, but the green contents, instead of having a spiral arrangement, assume the form of two star-shaped bodies or two globose masses in each cell. Conjugation takes place as it does in Spirogyra, the chief difference between them being in the arrangement of the endochrome. There

are other forms, called by long names, in which the endochrome is arranged in two transverse bands,[1] or with the cell contents diffused.[2]

ZYGNEMA.

There is an abundance of a branched Conferva[3] found attached to stones, piles, and other objects, but mostly in running streams, which exhibits another aspect in the history of the fresh-water Algæ. At certain times the whole of the endochrome contracts and becomes broken up into a large number of small bodies, called zoospores, each of which is furnished with two moveable cilia at one end. Swarms of these zoospores, produced in the manner we have stated, escape through orifices in the walls of the Conferva into the water, wherein they move freely with considerable agility. At one time these zoospores were believed to be confined to the Algæ, but they are now known also to prevail extensively in fungi. Not only does the potato disease maintain its hold chiefly through the great number and diffusibility of the zoospores, but also the disease to which fish are subject, including the form known as the "salmon disease,"[4]

ZOOSPORES.

[1] *Zygogonium.*
[2] *Mesocarpus.*
[3] *Cladophora glomerata.*
[4] *Saprolegnia.*

are dependent for their increase upon the myriads of zoospores which are produced. The immense amount of writing which already has been perpetrated in this country upon the subject is not only incomplete, but comparatively useless, from a want of appreciation of the methods by which the mould reproduces itself. It is amusing to read learned dissertations, compiled from foreign authors, in which no practical acquaintance with the subject can be traced, and from which the most important features are studiously omitted.

The genus *Ulothrix* is another example of a Conferva which freely produces zoospores. The species are of common occurrence in clear ponds, as well as running waters, the long streaming green threads being attached to stones and other objects. There appears to be a long investing cell, or sheath, in which shorter cells are packed, end to end, in a beaded manner. These cells contain an endochrome enclosing granules of a darker colour. Arrived at maturity, they may be seen to increase by division. The cell contents also divide into eight portions, each portion being converted into a ciliated zoospore, which escapes by the rupture of the cell-wall. After moving about in the water a little time, these zoospores become passive,

ULOTHRIX.[1]

[1] The letters *a* indicate the cells in process of division.

lose their cilia, and commence growing by lengthening gradually, becoming cylindrical, throwing divisions across, so as to separate the cylinder into joints or cells, and at last becoming a confervoid thread, like its parent.

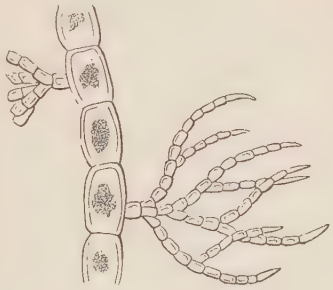
Dr. Hicks has shown, as the result of careful investigation, that, even amongst the filamentous Algæ, the same plant has received different names at different periods in its development. Particularly has he indicated that the threadlike form called *Lyngbya*, at a further stage of segmentation, or division of the endochrome, becomes what has been named *Schizogonium*, and that the ultimate, or adult condition, has received the separate name of *Prasiola*. "The only real difference," he says, "between the first two is that whereas Lyngbya is a tube containing distinct cells within, which when old undergo collateral subdivision to form a band of two, four, or eight rows of cells, Schizogonium is a band of two or eight rows of cells, which when young was but a single row, contained in a tube—which is only two different ways of stating the same facts. The comparison of the last two is of the same kind. For as Prasiola when old, is composed of many rows of cells, but which arose from a single row, there must have been a time in its life when it had two, four, or eight rows, and thus have been a Schizogonium, for there is no other structural difference between the two."[1] We cannot too strongly insist on this same writer's final dictum. "The study

[1] Hicks "on *Lyngbya*" in "Quart. Micro. Journ." 1861, p 163. Also "Popular Science Review," vol. vi. p. 1.

of the entire life-history is the only means towards the solution of the value of *species*."

Some apology is needed for this brief digression in favour of a subject rather beyond the scope of a volume such as the present. Were it not for this feeling, the observations might have been extended considerably. The conclusion is that until we know more of the life-history of the common fresh-water Algæ, we cannot affirm with any certainty whether one may not be a condition of another, or what relationship they may bear not only amongst themselves but also to plants of a higher organization.

More complex and branched forms of these water-weeds are represented by Draparnaldia,[1] found in low running streams and in ditches, adhering to sticks and stones. When first removed from the water it presents the appearance of a mass of coloured jelly, but on immersion again the branches expand. It will dry well when laid on paper, and recover its form again to a considerable extent when afterwards immersed. The plant is composed of a principal trunk, formed by a series of large cells,



DRAPARNALDIA.

[1] *Draparnaldia glomerata.*

placed end to end, each occupied with a ring of green matter. Branches arise from the junction of these cells, formed of articulated branched threads, which are slender, and terminated by a hairlike filament, much more gelatinous than the simple forms above described.

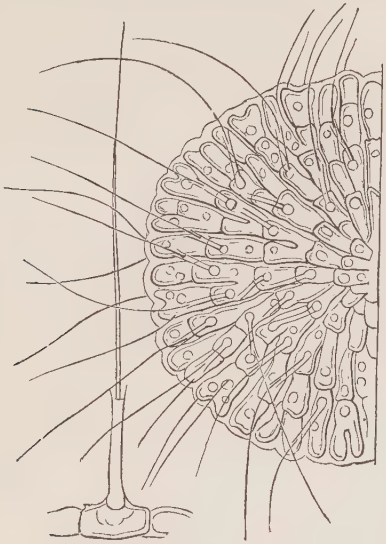
Chætophora is a similar branched Conferva, but it differs in the filaments being immersed in a gelatinous matrix. One species is common in slow-running streams,[1] and another equally or even more common in stagnant waters.[2] The tufts are very minute, so that it may easily be overlooked. The mode of branching resembles that of a stag's horns.

Here may be mentioned the peculiar little disc-shaped bodies so common in fresh-water pools, which attach themselves to leaves, sticks, and the larger Confervæ. As it has no popular name, we are compelled again to revert to the scientific, which in this instance is Colœochete.[3]

Although so minute, the discs may be distinguished by the naked eye, the green colour being conspicuous upon the discoloured plants to which they attach themselves. The forms are roundish, scarcely a line in diameter, formed of filaments radiating from the centre, forked towards the end, and so closely applied to each other as to appear to be glued together. The filaments are divided into cells, from many of which arises a slender tube: out of this projects a long threadlike filament. Such is the curious structure of this minute plant, which was first found in Normandy

[1] *Chætophora endiviæfolia.* [2] *Chætophora elegans.*
[3] *Colœochete scutata.*

growing on the Burr-weed and Pond-weeds, but has since been seen on a variety of aquatic plants, and will grow freely when transferred to an aquarium.



COLŒOCHETE.

There are other forms of discoid Algæ, and especially a pretty little one called Phyllactidium,[1] which was first found in this country a few years ago, but probably only another kind of Colœochete. We must pass on to one of the great favourites of pond collectors, and, notwithstanding its long and pedantic

[1] "Science-Gossip," 1867, p. 178.

name of Batrachospermum,[1] one that highly merits the esteem in which it is held. The most usual species is very variable in colour, sometimes verdigris green, or purple, or violet, or nearly black. The plants consist of delicate branched filaments, from one to three inches in length. Around the branches at regular distances grow dense whorls of *moniliform*, or beaded threads, mostly branched, forming large conspicuous tufts. The spores are produced in large numbers in each tuft. No verbal description can give an adequate idea of the beauty of the radiating tufts of beaded cells, as seen under the microscope.

BATRACHOSPERMUM.

The plant mostly delights in moving waters, but is occasionally found in nearly still water, provided it is clear and pure. It is often attached to the shells of fresh-water snails. Bory, who carefully studied these plants, gives the following curious fact regarding them: "It is upon individuals of this variety (*confusum*) that I made, for the first time, an experiment which ought to be known; after having many times carried

[1] *Batrachospermum moniliforme;* the meaning of the generic name of *Batrachospermum*, is "frog-spawn."

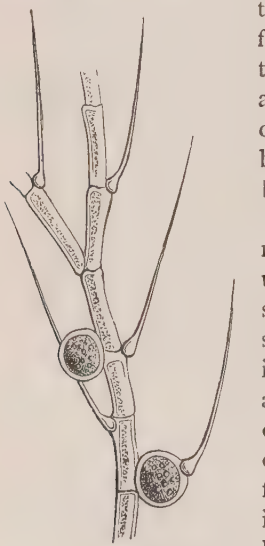
from one locality to another stones bearing individuals of this species, which continued to prosper in spite of the change of habitation, I steeped many of them in lukewarm water, afterwards in boiling, and no part of the Batrachosperm appeared, under the microscope, to have undergone the slightest disorganization by these immersions; and certain sprigs, replaced in their native place, continued to vegetate after these experiments. I do not think that there exist other vegetables which boiling water does not immediately disorganize; there are not others that can resist temperatures so opposite."

However necessary it may be to give some brief account of the features which these organisms present to the eye, in order to facilitate their determination, and give an interest to specimens which may be found, it is by no means attractive reading, and too free an indulgence would give reasonable cause for complaint against a book of such small pretensions. Hence we will rest content with another group of the genuine Confervæ, and then pass on to other Algæ.

The *Œdogoniaceæ* is a group, the name of which has almost become classical, on account of the large amount of literature which has been devoted to it. Some of the species are amongst the commonest and most abundant of fresh-water Algæ, being found in every pond, ditch, or stream, and some even making their appearance in aquaria. The entire structure and economy of this group would occupy too much of our space, so that we must content ourselves with referring at foot[1] to places where further information

[1] Dr. H. Wood, "Fresh-water Algæ of the United States,"

can be found. "They are small filamentous plants whose size is sufficient to render them visible to the naked eye, and yet not sufficient to make each individual distinctly apparent. They grow mostly in quiet water, attached to almost any and everything that can afford a foothold, fringing with apparent indifference stones, twigs, sticks, dead leaves, bits of glass, boards, &c. We have seen such masses of them crowding the whole surface of a small snail-shell as to entirely conceal the animal and its shell, and present the curious spectacle of a perambulating waving forest of bright green."



BULBOCHÆTE.

They are generally to be recognised by their dense and uniform green endochrome, sometimes filling the cells, sometimes retracted and leaving half the cell colourless, and, above all, by the ringed lines or striæ at the ends of many of the cells. In some the filaments are unbranched,[1] in others the filaments are branched, armed with bristles having a bulbous base.[2] They have all a complex system of reproduction by active

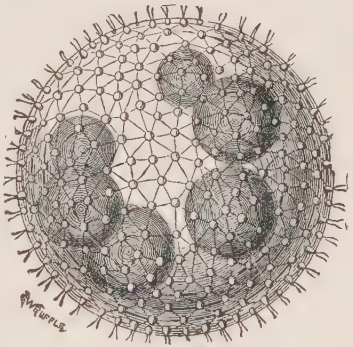
p. 190; "Micrographic Dictionary under Œdogonium"; and the works of De Bary, Thuret, Pringsheim, and others.

[1] *Œdogonium.* [2] *Bulbochæte.*

zoospores and by resting-spores, which latter rest during the winter and germinate in the following season.

Common species of *Cladophora* and *Oscillaria* will be found in every pond, and probably altogether not less than four hundred different kinds of Algæ in the British Isles, exclusive of the desmids and diatoms; so that our notice of them is essentially fragmentary.

The whole circle of pond-life includes no more interesting object than that called Volvox. It is found sometimes in considerable numbers in clear ponds, and though so minute as to measure only one-fiftieth of an inch in diameter, yet when a bottle of water containing them is held up against the light these little bodies may be seen by the naked eye as little movable green spots. This little organism when seen under a low power of the microscope is found to be a globe of transparent membrane of a delicate green colour, marked with fine lines in the form of network, with darker green spots at the points where the lines cross each other. Smaller, but similar, spheres may be seen rolling about within this parent globe. By means of a constant rolling motion the



VOLVOX.

Volvox glides gently through the water, or rather revolves within it, its young ones meanwhile revolving within itself. When viewed under a still higher power of the microscope, the green spots at the meeting of the lines are found to be clusters of delicate hairs, and doubtless it is owing to their action that the Volvox rolls through the water.

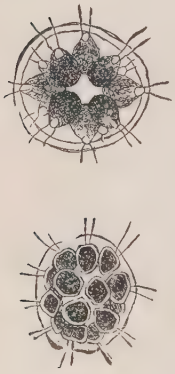
If by means of pressure between the glasses by which it is exhibited the sphere is broken, the outer membrane will be seen to resolve itself into a number of small cells, each with its bunch of hairs, and each cell capable of spontaneous motion in the water. For a long time it was considered as a low form of animal life, and was mixed with a heterogeneous company under the name of *Infusoria*. In these latter days it is grouped with the Algæ, and though endowed with the peculiar motion to which we have alluded, there is no reason why it should be considered an animal on that account, since zoospores with movable cilia are not at all uncommon amongst undoubted plants. Finally, when the old Volvox breaks up, the young ones escape from their temporary prison and float away on their own account, grow to the size of their parent, and enclose little rolling balls within themselves, as did their progenitor.

There are still points of obscurity about the history of these spheres: what becomes of them in winter? in what form and where do they rest? Do they produce the bodies called resting spores? These are questions still to be answered. It has always been rather difficult to preserve the Volvox after it has been collected; they seem to dislike confinement. Recently,

however, a successful experiment has been made, which is thus recorded :—"For several years the writer used to place the Volvox in large glass or earthenware jars, small bottles, open dishes, and other vessels exposed to full sun, or kept in partial or entire shade, supplying it with rain, pond, and spring water in turn, but always with the result that after a short time it disappeared. In October, 1878, however, he put a small quantity, probably not more than one hundred individuals, in a four-ounce bottle, having a mouth three-quarters of an inch in diameter, and set this on a shelf at the side of an out-house which had no gutter, so that the rain in running off the roof would drip into the bottle ; here it remained until November, 1879, and instead of the few original specimens, they had become abundant. The water had never been changed or replenished, only that which dripped naturally from the roof into the bottle having been added to the original stock, and during the abundant rains of the year the bottle often overflowed. Several times a portion of the water containing the Volvox has been placed in the jars and dishes standing in various parts of the garden, but these always died in a short time, whilst those left in the small bottle remained in perfect health and multiplied. The position in which the bottle was placed faced the north, so that it only got the sun in the early morning of the summer months. During the severe weather of the previous winter (1878–9) the water was several times frozen into a solid mass of ice, but apparently without injuring the Volvox."[1]

[1] N. E. Brown, in "Gardener's Chronicle," 1879, p. 599.

There is another, but smaller, nearly globose, revolving green organism, somewhat resembling a small volvox, which is found in equal profusion in ponds, and even in such profusion sometimes as to impart a green appearance to the water. This is the Pandorina.[1] There are two forms, one of which consists of sixteen, and the other of thirty-two green cells, termed *gonidia*, closely associated together within a gelatinous envelope of an oval form. Each green cell has a pair of cilia, or movable hairs, which protrude through the gelatinous envelope. They usually are not more than half the diameter of a volvox, and present a different appearance, so that there is no fear of any mistake in confounding the one with the other. Ultimately some of the green *gonidia* change colour, becoming brownish, acquire a thicker coat, and pass into resting spores, in which condition they remain a while, and then develop into a new generation, each resting spore originating a colony of either sixteen or thirty-two green gonidia, which constitutes the composite little plant called a Pandorina.



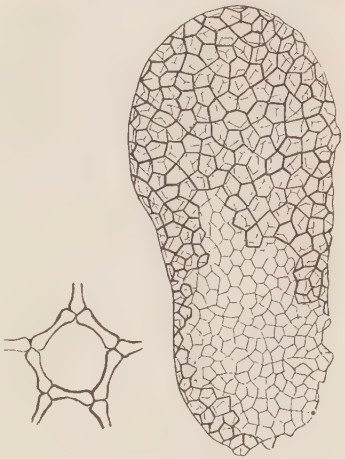
PANDORINA.

Nothing is so useful for a beginner in the study of these and similar objects as to be able to consult and examine the plants themselves. For such pur-

[1] *Pandorina morum.*

poses there have recently been prepared and issued certain small collections of mounted specimens of fresh-water Algæ and other plants ready for examination under the microscope.[1] Such preparations are far superior to any woodcuts or more elaborate illustrations, and will be found exceedingly valuable in order to familiarize the young student with the various types of structure which prevail in the different groups of his subject.

There still remain to us a large number of decidedly vegetable organisms, but of a very simple structure; profuse in all stagnant waters, and consisting of a single cell, or of a few cells associated together, or the simplest arrangement of simple cells. By far the most complex of these low forms of fresh-water Algæ is the "Water-net,"[2] in which the cells are combined into a net-work sac from an inch or two to six inches



WATER-NET.

[1] Information may be obtained on application to W. Joshua, Esq., F.L.S., Cirencester.

[2] *Hydrodictyon utriculatum.*

in length, and even more, but a complete skeleton-bag of the most fairylike character. Dr. Wood says that in the United States they frequently form floating masses several inches in thickness and many feet in extent, so that with the aid of a rake it could be collected by the bushel.[1] In this country, however, they are local, if not rare. But the more simple forms of what is termed the *Protococcus* group are abundant, and many of them but imperfect conditions or disintegrated forms of the more highly-developed Algæ.

"They are composed for the most part of only one cell of varying forms and colour, and are capable of growing, of dividing, or segmenting into many parts, and that in many directions, both round a common centre, through their long axis, or through their short one. The contents of the cell are also capable of resolving themselves by subdivision into numerous parts, not in any specific direction as above, by which there is formed a group of small cells within the parent cell-wall. Sometimes the parts separate from each other at once, sometimes they remain in contact for a variable period, whereby masses of cells are formed more or less connected, but without any definite arrangement or mutual dependence; so that any portion being separated is capable of continuing its growth without suffering injury. The size of the individual cells varies considerably, so that it seems impossible to limit the extent to which they may decrease by repeated segmentation. It may be carried

[1] Grevillea, vol. ii. p. 54.

to fine points, even seen under high microscopic powers, in which condition they have been called granules or molecules. These small fragments may, however, grow till they attain the size of their origin."[1]

Not only do they vary in dimensions, but also in colour, according to season and external conditions. In winter they become more or less red or brown, but with returning spring they resume a green tint. In fact, the varied features under which they present themselves are so puzzling, that Dr. Hicks was led to protest against any faith in such organisms as autonomous species, until their life-history is ascertained.

It has been the want of giving due importance to these considerations; the insisting with too implicit faith on the identity or difference of green cells; the attempting to give names and places to organisms of which nothing is known but a simple cell, that has led to the propagation of a theory with regard to lichens, called the "dual lichen hypothesis," which has obtained some adherents, and pertinacious defenders making spasmodic efforts in opposition to reason and fact.

The proper study and investigation of these little fresh-water plants is quite sufficient to absorb all the leisure of any one individual, and the result of such concentrated observation would bring a much more satisfactory reward than any amount of mere desultory observation. We suspect that anyone who follows this course would readily endorse the obser-

[1] Hicks, in "Popular Science Review," vol. iv. p. 335.

vations of our naturalist, Ray, with which this chapter concludes.

"God is said to be *maximus in minimis.* We men esteem it a more difficult matter, and of greater art and curiosity, to frame a small watch than a large clock. And no man blames him who spent his whole time in the consideration of the nature and works of a bee, or thinks his subject was too narrow. Let us not then esteem anything contemptible, or inconsiderable, or below our notice-taking; for this is to derogate from the wisdom and art of the Creator, and to confess ourselves unworthy of those endowments of knowledge and understanding which He hath bestowed on us. Do we praise Dædalus, and Archytas, and Hero, and Callicrates, and Albertus Magnus, and many others which I might mention, for their cunning in inventing, and dexterity in framing and composing a few dead engines or movements, and shall we not admire and magnify the great *Former of the world*, who hath made so many, yea, I may say, innumerable, rare pieces, and these too not dead ones, such as cease presently to move so soon as the spring is down; but all living, and themselves performing their own motions, and these so intricate and various, and requiring such a multitude of parts, and subordinate machines, that it is incomprehensible what art, and skill, and industry, must be employed in the framing of one of them?"

## CHAPTER V.

### DESMIDS.

NAMES are meaningless sounds until we are able to associate them with the objects which they represent. This is especially the case with Desmids, since there is nothing whatever in the name itself which could help a solution of the mystery as to what they are. This word is indeed a mutilated one, since it is a contraction, employed for convenience, of the longer and more pedantic word *Desmidiaceæ*, which is a scientific term representing a family, or order, of minute Algæ. These little plants are amongst the simplest, although not themselves the simplest, in the vegetable kingdom, since they consist of a single cell, variable in form, chiefly with green contents, and confined to fresh water. As they are unicellular Algæ, or Algæ consisting of a single cell, they are consequently very minute, so that their form is hardly to be distinguished by the naked eye.

Before we commence a description of the most common forms, it will be necessary to give some account of their habits and the places where they are to be found.[1] They are gregarious, being found in

[1] As this can only be done briefly and partially, the reader is referred for further assistance to a useful little volume called "The Collector's Handy Book," by J. Nave, published by D. Bogue.

such numbers as to give a green tint to the water or mud, when most prolific; and even when the colour is not apparent, numbers will be found together in bogs, ditches, or ponds which are exposed in bleak situations and not enclosed in woods, especially in little pools where the bog-moss (*Sphagnum*) abounds on heaths and damp moors. They love to flourish in holes and pools where the water is clear and pure, and the soil of a clayey nature, where they sometimes cover the bottom with a green film. Often numbers of them will be found adhering to the stems of sphagnum, from which they float when immersed and stirred about in clear water. The surface of wet rocks will afford some species when the pure water percolates and drips; hence some of the most interesting and varied collections have been made in mountainous districts, such as North Wales. The autumn is the best season for collecting them, but they will be found throughout the summer. When found coating the bottom of a pool with a green stratum, they may be taken up with a spoon and placed in a wide-mouthed bottle. After being shaken gently, so as to separate the mass, the bottle being placed in the light, the sediment will sink to the bottom and the Desmids will gradually rise to the light, and then they may be separated by decanting. If poured into a white soup-plate, the floating Desmids may be taken out on the tip of a camel-hair pencil with the aid of a pocket lens, and thus the largest specimens may be isolated. A little experience will soon prove the best guide to their manipulation. In order to see them as we shall describe them, a microscope with an inch

objective will be necessary, and even a higher power to make out the details.

All the Desmids consist of a transparent envelope or cell wall, enclosing a green colouring matter which is termed the endochrome. The differences in the form of this envelope and the disposition of the endochrome are the basis of the genera and species into which the Desmids are divided. Unfortunately, they have never been sufficiently known to acquire popular names, and hence our only alternative will be the employment of those adopted for scientific purposes.

CLOSTERIUM.

One of the largest and most common forms is *Closterium;* it is of little consequence which particular species, out of a great many, as the general form and character is the same. They are elongated, gradually narrowed towards each end, slightly curved like a new moon, or nearly straight, with a band or mark in the centre, and a clear space at each end. The central band indicates the point at which the cell ultimately divides, so that the endochrome escapes, and empty cells will sometimes be found in company with those containing the green endochrome. There are often darker longitudinal bands

in the endochrome and scattered paler spots or vesicles, which latter are sometimes symmetrically arranged. By careful observation a distinct circulation may be traced going on up and down near the margin of the cell in its living state. The various species of *Closterium* are from one-fortieth to 150th of an inch in length, and one-eighth to one-sixth of those dimensions in breadth. The largest only are visible to the naked eye.

The mode of reproduction is of two kinds, one by a gradual separation at the central band, when each half continues to grow and forms a separate and complete individual. This is the process of self-division. The other is when two individuals come in contact at the centre, and a globose body is formed between them, called a sporangium, or more correctly, zygospore, which in due time produces a great number of spores, and these develop into *Closteria*, individuals like the parent from which they sprung. This is the process of conjugation.

It has been stated, not uncommonly, in works on the microscope, that another mode of reproduction is found in Desmids, by means of zoospores.[1] It must be admitted, as not at all beyond the bounds of probability, that this mode of reproduction may be found to prevail to a limited extent. It is known that in other fresh-water Algæ these curious little bodies are developed, but hitherto, as far as we are aware, the evidence is very slight, and depends entirely upon the single instance, recorded by

[1] See fig. on page 52.

Mr. Archer, of Dublin.[1] After examining all the affirmations on this subject, and tracing them to their source, this gentleman came to the conclusion that no evidence could be found of the occurrence of zoospores in any Desmid up to the period of his communication. Afterwards he proceeds to a description of a peculiar condition of a Desmidian, called *Docidium*, which he met with, and in which bodies strongly resembling zoospores were seen. Hitherto these observations have not been confirmed, although, personally, we do not feel the least doubt of their accuracy.

First of all, the regular process of conjugation takes place thus. The conjugative act is not undertaken till after the two original fronds, about to conjugate, have undergone self-division in the usual manner, that is to say, by self-fission, effected by a division of the contents into two, just under the suture, accompanied by a development of a new cell-wall to each old segment; and separation taking place, the separated portions have now one long (and old) cone, and one more blunt and rounded (the nascent younger one). Now, in those individuals about to conjugate, from each of the shorter or younger cones is protruded a blunt, pouchlike projection from the lower and opposed sides of each, which, approaching gradually, the contents amalgamate with each other; at the same time, the other opposite portions of the original parent fronds acting in precisely the same manner. Thus two

[1] "Micro. Jour.," viii. (1860), p. 215.

sporangia (or zygospores) ultimately result from the two original fronds, conjugation taking place between each of the opposite individualized pairs of partially old, partially new, fronds, themselves resulting from the self-division of the original parent fronds.[1]

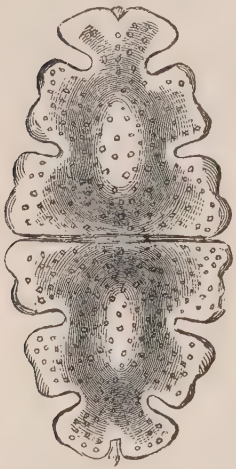
And now as to the bodies in question. The first indication of the commencement of the phenomenon is the production of a minute hyaline tubercle, just under the inflation at the base of the younger segment. This tubercle arises from a special extension of the boundary-wall interposed between the inflated base of the segment and the suture. It is, in effect, an addition to the base of one of the segments. This basal tubercle gradually elongates, and becomes a tube in direct connection and continuation of the frond, like the finger to a glove, and as of variable a length. Some cease to grow after reaching one-tenth or one-eighth of the length of the frond, whilst a few will grow nearly as long as the frond itself. The endochrome near the base of each segment becomes finely granular, of an almost homogeneous appearance, and the new tube is filled by it. The remainder of the endochrome is but little altered. The endochrome which had become granular, and filled the lateral tube, in the next change becomes segmented into a definite number of rounded portions, perhaps not less than twenty, or more than fifty. These spherical bodies formed by segmentation of the granular endo-

[1] See "Annals of Natural History," vol. v. (second series), p. 1, for further details.

chrome, in the next stage emerge from the open apex of the lateral tube, and remain clustered together in a mass, resembling a bunch of grapes; the clusters becoming larger and larger, until all the spherical bodies have emerged. Each of these appear to form for itself a special cell-wall of a slightly compressed or elliptical form, within which the green contents are seen to be somewhat retracted. Subsequently, a movement in the contents of each of these newly-formed cells is visible, which takes the appearance of a twisting motion, backwards and forwards, as it were, on its axis. This movement is not apparent in all the members of the group simultaneously, but only in a few at a time. Eventually the green bodies escape, and swim away as ovate or pear-shaped ciliated bodies, pale at the narrow or pointed end, in every way comparable to the mobile zoospores found in other Algæ. Whether one or two cilia were present cannot be determined. The old frond having performed its work, separates at the suture, and finally decays. Throughout this process, and in its final development, there is every reason to regard the phenomenon as a development of zoospores, differing in no very essential particular from those which are developed in *Chætophora*, and indeed in many other Algæ.

Another form equally common with Closterium is *Euastrum*. The cell, or frond, is flattened, lozenge-shaped or oblong, with a deep fissure on each side at the centre, so that the cell is nearly divided into two equal halves, the margin of each segment deeply waved or divided into lobes. The surface of the

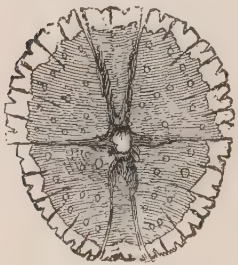
cell-wall, or envelope, is sprinkled with little elevated warts or prominences. The same modes of reproduction prevail with these as with *Closterium*, and, in fact, all the Desmids. The entire length of the largest specimens



EUASTRUM (*oblongum.*)

EUASTRUM (*didelta*).

does not exceed 150th of an inch, and many are not one-half that size.

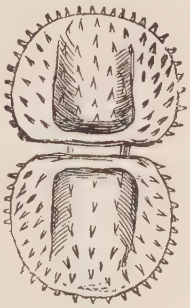


MICRASTERIAS.

In *Micrasterias*, the cell or frond is shorter, and more rounded than in *Euastrum*. It is divided on each side nearly to the middle into two equal segments, in a like manner, but each segment is more nearly semicircular. The margin is more deeply cleft into narrow lobes, which are often

toothed at the extremity. The individuals are usually larger than *Euastrum*, and often of very beautiful stellate forms.

In *Cosmarium* we have smaller forms, but some of the species are very common. The general outline is oval, deeply cut nearly to the centre into two equal segments, which are broader than long. There are no divisions or notches at the margin, and the frond (name applied to the whole plant) is more inflated than in the other forms. The surface of the cell-wall is often warted, as may best be seen in the empty fronds.



COSMARIUM.

We have now enumerated the common forms, of which some species is sure to be met with in favourable localities, but there still remain a few of the rarer Desmids, of which occasional examples may be seen intermixed with the commoner. One of these forms is that called *Penium*, which is elongated, nearly cylindrical, rounded at the ends, quite straight, in all of which it differs from *Closterium*, with which, perhaps, the novice is most likely to confound it. In one British species the fronds are, at the least, one-eightieth of an inch

PENIUM.

long ; in Wales it is said to be very common, and has been collected in the neighbourhood of London.

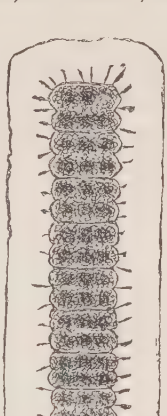
In *Docidium* the fronds are still more elongated, cylindrical, quite straight, and differing from Penium in being constricted at the centre.

SPIROTÆNIA.

*Spirotænia*, again, is similar in its cylindrical form, but with two important and distinctive features—viz., that the frond is surrounded by a clear gelatinous envelope, and the endochrome exhibits a spiral band. It is often difficult to see the gelatinous envelope, as it is so very transparent. We have found that a solution of any one of the aniline dyes is very useful in defining such structure under the microscope. If a small drop is placed at the end of the covering glass it will run in, tinge the water, leaving the margin of the hyaline envelope clearly and sharply defined. This little device is so simple and so invaluable that we marvel at its being so little known, or, at any rate, so little adopted.

To other forms of free swimming Desmids we need not allude, except to say that there are other rarer forms which must be studied in some work specially devoted to the group.

There are, however, two or three forms of Desmids in which the individual cells, or fronds, are gregarious, attached together in filaments, and surrounded by a gelatinous envelope which retains them in that position. Whether we call them *Hyalotheca*, or *Sphærozosma*, or *Didymoprium*, there is a great similarity between them, so much so that an unpractised eye would not detect the differences, which, after all, concern only the specialist. Take *Hyalotheca*, for example, and it consists of long fragile filaments, something like a conferva, very gelatinous, enclosing, or surrounding the joints, each of which is a separate individual, and in time the filaments will break up into the individual joints, each surrounded by a mucous envelope. The end view of each joint is circular, but the side view is quadrangular, broader than long, with a groove running round the centre of each cell or joint.



HYALOTHECA.

In other instances the end view is triangular, or quadrangular, but in Hyalotheca the filaments are cylindrical, so that the section is circular. Sporangia (or zygospores) are formed just as in other species.

Only one book has been written in this country devoted specially to the Desmids, and that has now

become very rare.[1] In the introduction its author (J. Ralfs) gives the following hints about collecting: —"In the water," he says, "the filamentous species resemble the zygnemata, but their green colour is generally paler and more opaque. They often occur in considerable quantity, and, notwithstanding their fragility, can generally be removed by the hand in the usual manner. When they are much diffused in the water, I take a piece of linen, about the size of a pocket-handkerchief, lay it on the ground in the form of a bag, and then, by the aid of a tin box, scoop up the water and strain it through the bag, repeating the process as often as may be required. The larger species of Euastrum, Micrasterias, Closterium, &c., are generally situated at the bottom of the pool, either spread out as a thin gelatinous stratum, or collected into finger-like tufts. If the finger be gently passed beneath them they will rise to the surface in little masses, and with care may be removed and strained through the linen as above described. At first nothing appears on the linen except a mere stain or a little dirt; but by repeated fillings up and straining a considerable quantity will be obtained. If not very gelatinous the water passes freely through the linen, from which the specimens can be scraped with a knife and transferred to a smaller piece; but in many species the fluid at length does not admit of being strained off without the employment of such force as would cause the fronds also to pass through, and in

[1] Cooke's "British Desmids," published since in 1 vol., with some hundreds of coloured figures.

this case it should be poured into bottles until they are quite full. But many species of staurastrum, pediastrum, &c., usually form a greenish or dirty cloud upon the stems and leaves of the filiform aquatic plants, and to collect them requires more care than is necessary in the former instances. In this state the slightest touch will break up the whole mass and disperse it through the water. I would recommend the following method as the best adapted for securing them. Let the hand be passed very gently into the water, and beneath the cloud, the palm upwards, and the fingers apart, so that the leaves or stem of the invested plant may lie between them, and as near the palm as possible; then close the fingers, and keeping the hand in the same position, but concave, draw it cautiously towards the surface, when, if the plant has been allowed to slip easily, and with an equable movement through the fingers, the Desmids in this way brushed off will be found lying in the palm. The greatest difficulty is in withdrawing the hand from the water, and probably but little will be retained at first; practice, however, will soon render the operation easy and successful. The contents of the hand should be transferred at once either to a bottle, or, in case much water has been taken up, into the box, and when this is full it can be emptied into the linen as before. But in this case the linen should be pressed gently, and a portion only of the water expelled, the remainder being poured into the bottle, and the process repeated as often as necessary."[1]

[1] Ralfs' "British Desmidiaceæ," p. 38.

Thus much with respect to collecting, but we cannot close the chapter with more appropriate observations than those with which the author just quoted concludes his "Introduction":—"What the Allwise did not disdain to create cannot be unworthy of notice; and if, in the minute Desmidiaceæ, so long concealed from the unassisted eye, we have been at length enabled to recognize objects as carefully organized as the bulky elephant or the majestic oak, and as happily adapted to their position in nature, possessing too an economy whose laws are no less constant and regular, shall we not gladly examine this fresh evidence of an Almighty hand, as distinctly impressed on them as on the rest of His creation?

"To Him no high, no low, no great, no small;
He fills, He bounds, connects, and equals all."

# CHAPTER VI.

## DIATOMS.

What are Diatoms? Microscopical aquatic plants, even as Desmids are, and like them consisting of a single cell, so that both are equally included under the name of Unicellular Algæ. This, however, is quite insufficient for an explanation of what the Diatoms are, for they have a singular history. At one time it was firmly believed that they were little animals; it is now as firmly declared that they must be plants. In writing of Desmids we intimated that, when living, their colour was a beautiful green; on the other hand, the Diatoms, when living, are as uniformly pale golden brown. There is, however, a still more characteristic feature in these minute plants, which is, that their skeleton is an indestructible pair of transparent plates, of the same substance as glass, that is to say, of silex or flint—two thin plates of flint applied to each other by their surfaces, and united by a marginal band. This is the type of structure in the Diatom skeleton. The endochrome or vital portion is coloured, but when the plant is dead, and the endochrome dissolved, the skeleton still remains, indestructible as flint. Century after century these delicate skeletons remain, until they accumulate and form immense beds, consisting of

the skeletons of myriads of Diatoms. It is a fact, often alluded to, that the city of Richmond, in Virginia, is built on a stratum of diatomaceous remains, sometimes eighteen feet in thickness. There are also other large tracts of fossilized Diatomaceæ in the United States and other parts of the world. Formerly these plants flourished in some sea, lake, or other expanse of water. They died, and the skeletons, being heavier than water, fell to the bottom, forming a thin layer over the mud. Year after year, and century after century, the little plants continued to multiply and to die, and contribute their skeletons to the stratum at the bottom, until at length, when the lake dried up, or its waters were diverted, the skeletons still remained, as an incontrovertible evidence of the existence of themselves, and the lake in which they flourished ages ago. Some of these deposits consist entirely of the skeletons of Diatoms. We have seen them so purely diatomaceous that the microscope could detect nothing else but these skeletons, or frustules, compacted into a friable mass. In Jutland the deposit is converted into a hard stone, containing some of the most beautiful of known forms.

It would be a mistake to suppose that because there is uniformity in the structure of these microscopical organisms, there would also be a great similarity of form. On the contrary, the form is exceedingly variable: some are circular or discoid, to a mathematical accuracy; others are triangular, quadrangular, polygonal, boat-shaped, oval, elliptical, fusiform, linear; in fact, the forms are numerous and diverse, but usually symmetrical. To increase their beauty and

our wonder, the surface is covered with the most delicate tracery of lines, dots, ribs, channels, spines, forming exquisite patterns, which require very high powers of the microscope to reveal in all their delicacy. And yet very few of these minute plates or frustules are visible to the naked eye. More beautiful geometrical patterns can scarcely be conceived than those of some of the discoid Diatomaceæ. No stronger evidence need be sought of the infinite power and wisdom of the great Creator of all.

The indestructibility of these skeletons serves to indicate the universality of these little plants. They are to be found almost everywhere. We take a tuft of bog-moss, and rinse it well in a vessel of clean water, then, with a dipping-tube, draw up a drop from the bottom of the vessel, place it under the microscope, and behold five or six different kinds of Diatoms. Desiccate an oyster, destroy all its animal substance, and still there remain skeletons of Diatoms. The guano, which is brought over to this country for manure, contains large numbers of them, devoured by sea-birds, deposited in their excrements, and exported as guano. In fact, they flourish in salt water, or fresh water, but especially in the former, everywhere; are devoured in turns by aquatic animals of all kinds, and hence find their way into the most unsuspected places, so that they are almost ubiquitous.

"I suppose," says Nave, "that there is scarcely a single piece of water anywhere which does not contain at least some individuals of the commoner species. They are to be found alike in the lake

that crowns the mountain top, and the swamps and peat-beds which fill the lowest valley; in the water course employed to irrigate the meadows; in the broad ocean, and the shallow puddle left by the overflowing of a ditch; the brackish water, where the tidal river meets the sea; salt-works and salt-pits; even inland lakes, which have a trace of salt in them — each affords a rich variety of characteristic Diatomaceæ, varying according to the chemical quality of the water. They are to be frequently found also on rocks and masses of stone, damp from overhanging trees, or from the constant trickling of water."[1]

Many of these localities are not within our jurisdiction, but Diatoms are plentiful enough in pools, ponds, and ditches. The most beautiful and largest forms are marine, but the fresh-water species are by no means few or insignificant. We have already indicated the readiness with which they flourish amongst the bog-mosses (*Sphagnum*) in swampy places. The earliest and surest effort of the young collector should be directed to this source, by means of which he will make a first acquaintance with the Diatomaceæ.

We are indebted to the generous aid of a friend,[2] who has devoted himself specially to the study of these minute organisms, for the residue of this chapter. On such a subject his words would possess more authority than our own, and we willingly acknowledge his ready assistance.

[1] Nave's "Collector's Handy Book."
[2] F. Kitton, Hon. F.R.M.S.

The tyro in the study of pond life has no doubt observed certain minute organisms differing in form and colour from the surrounding objects, some of which move about with considerable activity. The colouring matter, unlike that of the majority of minute vegetable forms, is usually of a golden-brown colour. These organisms are now generally known as Diatomaceæ or Diatoms. The first discovered representative of this order was the so-called "Oat animalcule;" the discoverer was a Mr. William Arderon, F.R.S., who found it in a ditch in Norwich, in 1745; it was afterwards described in Baker's "Employment for the Microscope." This form was some species of the genus Navicula. These organisms were called by early observers Bacillaria, or "Staff animalcules," a term still retained by some of the German observers. Agardh introduced the name Diatomæ, deriving it from the genus Diatoma (*diatomé*, incision), a filamentous form, of which the cells composing the filament cohere at their alternate angles, having the appearance of a band nearly cut through in opposite directions. Both names are open to objection, as they only indicate the characters of a few genera.

The position of the Diatomaceæ has long puzzled the student: some microscopists contended for their animal and others for their vegetable nature (the great Ehrenberg always maintained the former opinion, and placed them with the Desmidiæ and some forms of true animalculæ in his family Polygastrica—many-stomached); others were equally positive that their true place was in the vegetable kingdom; others again considered them to be plant animals (Phytozoa);

some few even placed them in the mineral kingdom. The now generally received opinion is that the Diatomaceæ are true unicellular Algæ, differing however in many important points from any other forms in that group. The principal are, first, the nature of the cell-wall, which is composed of silex or flint,[1] secreted by a thin membrane; second, their mode of increase by a self-division;[2] third, the peculiar nature of the cell contents, which contain a colouring matter not found in other Algæ, and which is called Diatomine. The diatom cell is usually described as resembling a pill-box. This is a tolerably good description so far as the circular forms are concerned, but the comparison is somewhat obscure to the "staff-shaped" species. We will now endeavour to describe, in as plain and brief a manner as possible, the structure of the Diatom cell.

The structure is most easily discerned in the circular form. In its earliest condition the cell has the appearance of a double convex lens, but as growth proceeds the convex surfaces recede, and a band is formed by the sides of the pill-box, which gradually increases in breadth. If we take two pill-boxes (minus the lids), which we will call *a* and *b*, the latter small enough to slide into the former, we have a fairly correct idea of the Diatom cell.

When this cell has attained its maximum develop

[1] The flinty nature of the Diatom cell was first demonstrated by Kütz in 1834.

[2] Increase by self-division is not peculiar to the Diatomaceæ, but the manner in which this takes place differs from that in any other form of Algæ.

ment the cell contents begin to divide, one portion receding to one end of the cell and the second to the other, and in a short time a new end is formed to *a*, and we have a cell in all respects like the first. The same occurs with *b*. We have now two perfect cells, one of which is smaller than the other by the thickness of the band; in the free forms the cells usually separate, but in many genera the cells continue attached, thus forming a filament or chain. This process goes on until the productive energy is destroyed, but the number produced by the parent cell is probably very large. We have many times carefully measured the thickness of this band, and never found it exceed the $\frac{1}{10000}$ of an inch in thickness.

The shape of the Diatom cell is very variable; they occur circular, oval, triangular, square, 5, 6, 7, 8, and 10 sided, boat-shaped, wand-like, sometimes curved in opposite directions, sometimes only in one. But the structure is always the same, viz., the two lids and the band connecting them. The former are usually termed valves, and the latter the connecting zone or cingulum. It is from the form of, and the markings on, the valves that the generic and specific distinctions are principally constituted.[1] These markings are generally of great beauty, and usually require the highest microscopic powers to show all their details, particularly those forms on which the markings appear as fine lines, the so-called test objects. One species

[1] Some foreign diatomists have proposed to classify these organisms according to the arrangement of the cell contents, but as this can only be studied during the life of the Diatom, it has not met with general acceptance.

(*Amphipleura pellucida*) in particular has lines so close that as many as 94 in the $\frac{1}{1000}$ of an inch have been counted, and, by certain arrangements of the light, these lines are found not to be continuous but composed of minute dots. The nature of these markings has always been a disputed question, some asserting that they are elevations on the surface, whilst others have been equally positive that they are minute cells in the siliceous wall. That the latter theory is true in some species has, we think, been clearly demonstrated in some of the large marine forms, but it is not so evident in the more delicate species. Some genera are usually found attached to the larger Algæ by non-siliceous stalks, whilst others are enclosed in membraneous tubes generally of a green colour and sometimes several inches in length; they then have the appearance of delicate filamentous Algæ.

The movements of the Diatoms excited the wonder and curiosity of the earliest observers, and was a great argument in favour of their animal nature. The means by which these movements are produced has not yet been explained. By some it was supposed to be caused by the extension and retraction of a foot or feet, and by others the expulsion of water from the ends of the cell. It is only among the elongated, or staff-shaped forms, that these movements are conspicuous, but that all non-parasitic forms possess the power of locomotion can be proved by placing a gathering containing them in the sunshine, when they will be found in a short time on the surface mud, appearing like a film of a golden-brown colour.

These organisms occur in fossil deposits in all parts of the world, sometimes forming beds of considerable extent and great thickness. We received a few years ago a specimen of deposit occurring in Australia, evidently the bottom of an ancient lake many acres in extent. This deposit was stated to be twelve feet in thickness, and consisted almost entirely of the remains of a small Synedra (the largest did not exceed $\frac{1}{150}$ of an inch in length and $\frac{1}{700}$ in breadth). The mind is incapable of conceiving the enormous number of individuals composing this deposit.

As it is not our intention in this work to give any minute scientific classification or specific description of the objects to be found in our ponds and ditches, we shall only describe those diatoms which are most likely to be met with in such places.

The prevailing forms in fresh-water are bacillar, or staff-like, of which the *Naviculæ* (little ships) group afford the largest number. This group is distinguished (with one or two exceptions) by the valve being divided longitudinally by a line, in the centre of which is a central spot (nodule) more or less conspicuous, and terminating with two smaller spots. The following are a few of the forms which are most likely to be found in ponds and ditches :—

Of the boat-shaped forms belonging to the genus *Navicula*, the Spotted Navicula[1] first deserves notice. It is of an oval form, with blunt, beak-like ends. When dry it has a very distinct circular spot in the centre of the valve, and two smaller ones at each end.

[1] *Navicula sphærophora.*

Another, very much resembling this in shape, is called "Amphisbæna."[1] If we consult the lexicon we find that the original amphisbæna was a snake having a head at both ends, so that it was capable of moving both ways. The amphisbæna diatom does not taper so gradually towards the ends as in the preceding species, and the beaks are broader. When dry, a broad marginal band of a pale brown colour surrounds the valve, leaving an oval transparent space in the centre. This band, when properly illuminated under the microscope, will be found to be composed of fine parallel lines.

As these minute objects have no popular names of their own, it would scarce serve any good purpose to invent them, and it is better to adopt the practice which prevails with the majority of microscopists of calling them by their trivial names. Thus, the next species is "serians,"[2] and this may be remembered as readily as a more commonplace name. This species is narrower than the last, and the margins gradually taper towards the ends, which are abruptly pointed. When dry, the central spot is very conspicuous, and rows of longitudinal lines are visible on the valve.

NAVICULA SERIANS.

A much larger form than any of the preceding is "cuspidata."[3] The valve has a somewhat angular

[1] *Navicula amphisbæna.* [2] *Navicula serians.*
[3] *Navicula cuspidata.*

outline, with the ends slightly rounded. In the dry state it is transparent, with a very slight pink tinge, and has distinct transverse lines reaching to the centre.

The next is "rhomboides,"[1] and has a reputation beyond the ranks of the diatom-hunters, for reasons which will presently appear. It very much resembles the former species, but is not more than half its size. It is perfectly transparent when dry, and the markings on the valve are only visible when examined by glasses of the most perfect construction. The resolution of these lines is usually considered an excellent test of the accuracy of the optician's work, so that "rhomboides" enjoys the reputation of being one of the so-called "test-objects," by which the quality of microscope lenses is tested.

NAVICULA RHOMBOIDES.

Although there are many other species of this genus, we will now pass to another, called *Pinnularia*, which has a close relationship with *Navicula*, but is distinguished by the coarseness of the transverse markings, and the fact that they cannot be resolved into dots, as is the case with the finer lines on the true species of Navicula. The first species is called "viridis,"[2] and is one of the most common of fresh-water diatoms. It has an elliptical outline, with rounded ends; the markings nearly extend to the line which passes down the centre, and in the centre of this a nodule is very

[1] *Navicula rhomboides.* [2] *Pinnularia viridis.*

distinctly apparent. A friend suggests that it has been called *viridis* because it is never "green."

PINNULARIA MAJOR.

Another species, of which we have given a figure, is called "major."[1] It has nearly straight sides, with broadly-rounded ends, the markings, or ribs, are conspicuous, and the central nodule large.

A still larger form is that called "gigas,"[2] which resembles the preceding, but the costæ, or ribs, are more distinct. It is most frequently found in boggy pools in elevated districts. There is a much smaller species called "lata,"[3] which is easily identified by its distant and conspicuous ribs, which become shorter as they approach the central nodule. It is only found in sub-alpine localities. Another, called "Alpina,"[4] is frequently found associated with it. This is larger, and has a more elliptical outline than "lata," which, however, it resembles in its conspicuous and distant ribs.

There is another group, or genus, to which the name of *Stauroneis* is given, and its difference from the preceding may be easily recognised by comparison of the figures. The outline is that of *Navicula*, but from this they are distinguished by a smooth central band crossing the middle of the valve. The one

[1] *Pinnularia major.*
[2] *Pinnularia gigas.*
[3] *Pinnularia lata.*
[4] *Pinnularia alpina.*

called "phænicenteron,"[1] of which we have given a figure, has the outline of that Navicula which is termed "cuspidata," but from this it can readily be distinguished, when dry, by the central band and its darker colour.

STAURONEIS PHŒNICENTERON.

The peculiar movement, of which we have already spoken, is perhaps nowhere better seen than in a group of diatoms called Pleurosigma. They are easily recognised by their sigmoid outline, the central or median line usually having the same curvature as the margins. The larger proportion of species are only found in salt or brackish water; the one called "attenuatum,"[2] however, is common in fresh water. When dry it is of a purplish colour, and the surface is covered with dots arranged in straight lines.

Whilst examining specimens of the delicate filamentous Algæ usually known by the name of Confervæ, the observer is almost certain to detect little needle-like tufts attached to them. These are sometimes so numerous as to give a spiny appearance to the filament. These are diatoms belonging to the genus *Synedra*, which contains a great number of species, many of which are common in fresh water. There are two kinds which are almost certain to be found

[1] *Stauroneis phœnicenteron.* [2] *Pleurosigma attenuatum.*

That called "capitata"[1] is long and narrow, with straight sides, the ends suddenly expanded into a wedge-shape; in the centre is a small round space, the remainder of the valve being covered with straight lines of dots. The other species, "radians,"[2] differs from the preceding by the margins gradually tapering towards the ends, which are rounded. When living it grows attached in star-like tufts. It may be added that these are minute species as compared with the majority of those immediately preceding.

Amongst the disc-shaped forms found in ponds and ditches are species of the genus *Campylodiscus;* a long name, it is true, but the objects are well worthy of an aristocratic name. This genus is easily recognised by the valves being saddle-shaped, or bent in opposite directions. The one most commonly met with has the centre of the valve smooth,[3] or finely dotted, surrounded by a broad margin of distant stout lines.

Somewhat related to the foregoing is the genus called *Surirella*, and, indeed, some of the species bear considerable resemblance to *Campylodiscus.*

Amongst fresh-water species the following may be indicated. The one is "biseriata,"[4] having a narrow oval shape, with pointed ends. The centre of the valve has a narrow, smooth line, running from end to end, and separating the conspicuous transverse bands or folds. The other is "nobilis,"[5] less common than the preceding, but nevertheless frequent in sub-alpine

[1] *Synedra capitata.*
[2] *Synedra radians.*
[3] *Campylodiscus costatus.*
[4] *Surirella biseriata.*
[5] *Surirella nobilis.*

pools. The valve is egg-shaped, the folds distant, reaching the median space.

We have passed rather rapidly over these dry details of some of the more common forms, more for the purpose of indicating the variety to be met with, and to serve as types, rather than to furnish an exhaustive catalogue, which would have been drier still. Only a few remain which demand a passing observation. A genus of parasitic diatoms will often be found, in some of its forms, infesting not only the larger Algæ but also other diatoms, adhering like the common "scale insect," or *coccus*, from which its name of *Cocconeis* is derived. The only freshwater species that we have in this country are those called *Pediculus* and *Placentula*. They differ slightly in general appearance; the valves in both species are marked with fine longitudinal lines, and have a series of small dots surrounding the inner margin. The principal distinction is that the former is more broadly oval than the latter, and the ends less pointed.

COCCONEIS.

One other type is *Cocconema*, of which the species we have in view [1] is of very frequent occurrence, and is easily recognised by its bow-shaped outline and beadlike markings. In this genus the median line is no longer central, but is more or less close to the inner or concave margin. The species are frequently

[1] *Cocconema lanceolatum*.

attached at one end to a long stalk, by means of which they adhere to other Algæ.

COCCONEMA.

In order to distinguish the generic and specific characteristics of the Diatomaceæ, it is generally necessary to get rid of the cell contents, and separate the valves. This may be accomplished by boiling in nitric acid, and afterwards washing in distilled water until all traces of acid disappear. The details of this process will be found in any of the excellent treatises on the use of the microscope.

NOTE.—The classic book on Diatoms in this country is "A Synopsis of British Diatomaceæ," by William Smith, F.L.S., in 2 vols., 1856. Much information on the subject will be found in the "Micrographic Dictionary" and in Pritchard's "Infusoria."

## CHAPTER VII.

### LOW-LIFE (PROTOZOA).

We have reached the borderland between the vegetable and animal kingdom, where the organisms on both sides are reduced to a simple cell, where our real knowledge is small and our presumption is great. We know from experience that small bodies which consist of a single cell, can move about with as much freedom and vivacity as animals, and yet these bodies emanate from, and are capable of producing, undoubted plants. The old notions of what constituted an animal and what a plant, have now melted into the air, and we are compelled to admit the difficulty, if not impossibility, of defining in words the limit between animal and plant, when each is reduced to its lowest terms.

The warm controversy which raged but a year or two ago has subsided into a calm. This controversy on atoms and spontaneous generation, and heterogeny, or by whatever name it was called, doubtless commenced in France, and thence spread over Europe. It was an old axiom, or a saying treated as an axiom, that every living thing proceeded from an egg or germ derived from a similar parent. That not only did a hen proceed from a hen's egg, but all other animals,

and even plants, from a germ-cell, which was equivalent to an egg. It was supposed that given cells, produced, for example, from a low form of Algæ, or water-weed, would in turn develope into a similar water-weed. That in some cases there might be intermediate stages, a kind of alternation of generations, but ultimately the child would resemble its parent. This is something like panspermy. The pansperm-ists held that from certain definite germs organized beings originate in accordance with inflexible law; that, for instance, toads are not hatched from hen's eggs but from toad-spawn; whereas, on the contrary, the heterogenists held that from certain germs, either plants or animals may be developed, as circumstances favour the one or the other; in effect, it was haphazard as to what the latent germ would produce.

It is confessedly difficult to determine when certain little bodies are floating about on the field of the microscope whether they are animal or vegetable. They behave themselves, for a time, just like animals, but if their development be followed they may culminate in vegetable organisms. The conclusion has been guessed at, rather than demonstrated, that these active little bodies may, according to the conditions in which they are placed, eventually become either plants or animals. Even if it be admitted that "the very lowest forms of vegetable and animal life cannot be traced back to spores or ova," it by no means follows that they could not originate from spores or ova. The emphasis belongs to the word "traced." We cannot admit that in the operations of Nature there is any such uncertainty as to the destination of

the smallest atom as the heterogenists assumed. Practically, however, the controversy is over. Admittedly it failed to demonstrate what it assumed, and there is no longer any reason to show battle against it, but it may reappear in another form. Meanwhile, it behoves us to endeavour to comprehend, as far as we can, the mysteries of life as exhibited in its lowest forms.

> "For He whose mercy is o'er all His works
> Forgot not one of this large family,
> But cared for each as for an only child."

There is a very simple animal with a low form of organization, which has been called the Proteus from its habit of constantly changing its form. In ditches, water-butts, stagnant water of all kinds, this little creature is to be found. A little microscopical animal, so colourless and transparent as to be almost invisible from the very gelatinous character of its substance. It is, in fact, a little lump of jelly, vivified jelly, moving jelly, but still a jelly, and scarcely anything more. It is just what naturalists call a piece of protoplasm, and a most anomalous creature it seems to be. Imagine a minute speck of isinglass jelly endued with life, and you have an Amœba, a Proteus, a Rhizopod without a shell. It has no mouth, no eyes, no legs, no hands, no feet, no stomach; yet it performs the functions of all these. No mouth, yet it extemporizes a mouth from any portion of its surface, involves, and draws in its prey; no legs, yet it elongates and pushes out any portion of its gelatinous substance like a leg to move itself about. No stomach, yet it takes food, and gathers it into the

midst of its gelatinous mass, digests it, and rejects the undigested portions. Now it is almost spherical, then it becomes oblong, lengthens itself into a long and narrow body, and then as speedily becomes triangular, or star-shaped, or many-sided. In fact, it is a very Proteus, every instant changing its form and assuming every shape of which a plastic lump of gelatine is capable.

PROTEUS, OR AMŒBA.

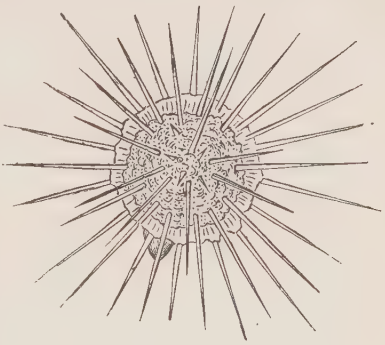
Put this creature inside a shell, in shape like a bottle, a flask, or a snail-shell, and it becomes a Foraminifer, protruding its jelly-like substance through the pores of the shell, like false feet, and thus moving itself about. Or place it in a flinty skeleton of variable shape, and it becomes a Polycystin. Or give it a horny skeleton, strengthened with ribs of flint, and collect myriads of individuals into a collective mass, and we have a sponge. Sarcode, or protoplasm, or whatever else you may please to call this living jelly, it is typically the same in all these creatures, which are really animals in such a simple condition that, instead of possessing special organs, endowed with

particular functions, these functions are performed by any portion of the body, which is sometimes mouth, or leg, or arm, or stomach ;

"All things by turns, and nothing long."

If one of these creatures, which we call an Amœba, or Proteus, should be subjected to such a squeeze as to separate it into two portions, each one starts off on a separate existence, and becomes a Proteus on its own account. On the other hand, two individuals will meet sometimes so cordially that they will melt into each other, and they twain literally become one flesh.

Nearly allied to the Amœba is a little animal called the "Sun-animalcule,"[1] which may sometimes be found in the dirty scum floating on the surface of standing water, or amongst Confervæ and other plants, "even when the plants are decomposed and the water has become offensive." They differ in size, some being minute, others large enough to be seen by the naked eye. The animal is of a flattened form, orbicular



LARGE ACTINOPHRYS.

[1] *Actinophrys sol.*

in shape, of a whitish colour, with rays or tentacles diverging from every part of the body, which, Ehrenberg says "serve to move, to feel, and to catch." When the minute Infusoria, with which such water swarms, come in contact with these tentacles they contract, and the entangled Infusorian is absorbed into the body of the animal. The conjugation of these animals has been described by several observers, and various interpretations offered in explanation of the phenomenon.[1] One difference to be observed between the Amœba and the Sun-animalcule is, that in the latter the locomotive organs, or tentacles, are permanent, whereas in the former they are temporary. We have given figures of two species of these Sun-animalcules.

ACTINOPHRYS SOL.

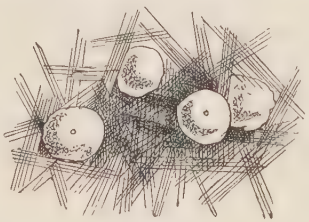
A very little advance in organization is to be seen in Difflugia, of which there are numerous species found amongst Confervæ, and dispersed over still waters. This slight advance consists of an external horny covering or shell, which is pitcher-shaped, with a narrow opening through which the pseudopodia, or extemporized tentacles, are protruded.

DIFFLUGIA.

[1] See Waller on *Actinophrys sol* in "Quekett Journal," No. 12.

Without lingering further amongst these minute forms, let us proceed to the examination of very visible Protozoa as exhibited in Fresh-water Sponges. Of these two are British, called respectively the River Sponge[1] and the Lake Sponge.[2] Although called by these distinctive names, they may often be found growing in the same locality, and within a short distance of each other. It is true that they have been confounded, the one with the other, for the want of due care, but they are really so dissimilar, that there is no excuse for the error. The Lake Sponge grows in long, branching, lobed forms, and the River Sponge in large unsymmetrical masses. Colour is variable according to light, but generally the Lake Sponge is of a dark green, whilst the River Sponge is of a paler yellowish or greenish tint.

The Fresh-water Sponge is commonly fished up from ponds, reservoirs, and docks, and may often be found adhering to the woodwork of locks and weirs. Throughout the course of the Thames it is tolerably common. At one time there were many persons who contended strongly that the Fresh-water Sponge was not an animal but



GEMMULES OF FRESH-WATER SPONGE.

[1] *Spongilla fluviatilis.* [2] *Spongilla lacustris.*

a vegetable, and this position they held to be strengthened by the fact that its green colour was subject to the influence of light, and was chiefly developed under that influence.

The sponge, in its fresh state, is by no means an attractive object, it has no beauty in form or colour, and its odour is scarcely inviting. The entire substance consists of a gelatinous mass, called sarcode, in which are imbedded numerous long, slender, firm, needle-shaped bodies which are called spicules. The combination of the needle-like bodies forms a skeleton which supports and gives firmness to the gelatinous sarcode. The spicules, like needles of glass, are composed of silex or flint; and the sarcode is a jelly formed of an agglomeration of bodies like the Proteus into a mass. In the fresh-water sponges we have a type of the great majority of marine sponges, that is, a flinty or glassy skeleton of spicules immersed in a mass of jelly. The soft sponges of commerce are an exception, as they do not contain such a flinty skeleton.

Enclosed within the substance of the Fresh-water Sponge small seed-like bodies are commonly found, to which the name of gemmules has been applied. These contain spicules differing in form from those composing the skeleton of the sponge. So much has been written about these sponges of the fresh waters and their life-history,[1] that we need only refer to the sources where more explicit information may be found,

[1] Bowerbank, "British Spongiadæ;" Williamson in "Pop. Science Review," vol. vii. p. 1.

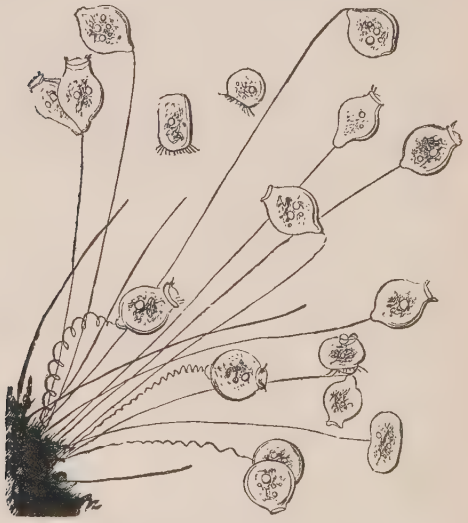
and especially to some observations on gemmules and young sponges by Mr. J. G. Waller.[1]

If water which contains dead vegetable substances, such as hay, grass, leaves, herbaceous stems, be exposed for a little time to the influence of the atmosphere, we shall find, on examining it with the microscope, that it contains swarms of active little creatures, moving about in all directions, and it was to such animals, found under such conditions, that the name of Infusoria was applied in times past. At that period, not so very remote, the name of Infusoria was given indiscriminately to a vast number of organisms, some vegetable, some animal, of which many, now much better known and understood, have been transferred to other positions, with other names. As at present limited the Infusoria possibly includes many disputed organisms, but it is at any rate a very much smaller group than formerly, and the term itself will probably soon pass out of use.

The Bell-flower animalcule, or Vorticella, is one of the most attractive of the Infusoria, and may be found in infusions of vegetable substances, or attached to duckweed and other living plants. The body is bell-shaped, and its mouth ornamented with a fringe of vibratile cilia. This body is seated on a hollow, long, elastic stem, which constantly contracts and elongates alternately, so that the body is moved up and down, whilst the base or lowest extremity is attached to the object on which it is found. The structure of the body has been thus familiarly explained — "The only familiar object with which I can

[1] "Quekett Micro. Journ.," iii., p. 42.

compare it"—the cup of Vorticella—"is a common breakfast-cup, into which a circular piece of pasteboard has been inserted, so as to leave only the rim of the cup visible. Suppose you were to cut a piece of paper or cardboard to the shape of the cup at its widest part, and make a hole in the cardboard a little



BELL-FLOWER ANIMALCULE.

to one side from the centre, you would imitate, to some extent, the 'disk' as it is called, which closes the wide aperture of the cup of Vorticella. The circlet of cilia is disposed spirally upon the disk within the lip or rim, and is continued a little way into the

mouth or oral aperture, which is represented by the hole in the cardboard that closes the aperture of the cup."[1] The movements of these cilia cause a vortex, into which minute animalculæ are drawn, and thus they pass into the body of the Vorticella.

There are many curious and interesting features in the life-history of these little creatures; one is that they are able to reproduce themselves by division, that is, the cup divides itself down the middle and down the stem. It constricts all the way down, and the two opposite sides draw in gradually until they meet each other, when in course of time two cups and two stems are formed out of one, which separate from each other, and work as independently as if they had never been united. Another mode of increase is by the budding of young cups from the side of the parent cup. The third mode is called the encysting process. At a certain stage the animalcule shrinks up into a ball, a gelatinous substance exudes from its body and encloses it. In this condition it rests for a time, whilst a swarm of little oval animalcules are being formed in the interior. As the young brood grow, the outer covering is distended until it can no longer resist, when it bursts, and the imprisoned progeny are set free.

A compound Vorticella, as it might be termed, consisting of a common trunk, with the individual infusoria attached to it by their thread-like stems, is known by the name of *Epistylis*, of which there are

[1] "Popular Science Review," i., p. 151.

several species; some attach themselves to the hornwort and other growing plants, others are parasitic on water-snails or water-fleas, or other aquatic animals. The pedicel is rigid, and not contractile, as in *Vorticella*. This rigid pedicel is characteristic of Epistylis, which sometimes is simple and unbranched, as in Vorticella.[1]

STENTOR MULLERI.

The largest infusorian, however, is Stentor, which is sometimes 1-25th of an inch in length, and all the species are visible to the naked eye. They are excessively fond of fresh standing water, and lie sheltered amongst plants where the water is still. The "funnel polyp,"[2] as it was once called, when outstretched is trumpet-shaped, with a crown or wreath of cilia, which form an interrupted fringe; when contracted, it throws out a gelatinous mass as an outer covering. Dr. Wright says that the Stentor always secretes a gelatinous case into which it can retract when necessary. Stentors sometimes collect together in clusters and attach themselves to plants, hanging head

[1] The most elaborately branched and tree-like Infusoria are those named *Carchesium*.

[2] *Stentor Mulleri*.

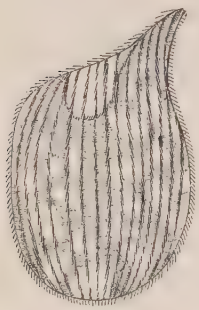
downwards. They are often to be found on duck-weed, and also abundantly on the American Pond-weed (Anacharis), independent of cold or ice. Mr. Slack, describing his adventures amongst the Stentors, says :—"After leaving the Anacharis in a glass jar for a few days, the Stentors multiplied exceedingly; some clung to the sides of the vessel in sociable communities, others hung from the surface of the water, and crowds settled upon the stems, visibly changing their tint, as the Stentor green was much bluer than the plant. Scores swam about in all sorts of forms. Now they looked like cylindrical vessels with expanding brims, now globular, now oddly distorted, until all semblance of the original shape was lost. In many cases they were found in shining tubes, but these were never so lively or green as the free swimmers, but mostly of a dingy, dirty hue. These housekeepers were more timid and cautious than the roving tribe. They came slowly out of their dens, drew back at the slightest alarm, never took their tails from home, and only extended their full length when certain not to be disturbed."[1]

It would not avail to attempt to describe all the minute forms of ciliated infusoria which will be found in dippings from ponds and ditches, or in any extempore aquarium which may be constructed out of a glass jar, or even a basin, into which bottles of duck-weed, pond-weed, and other pond gatherings are emptied on the return home of the diligent collector.

The ovate bodies of Paramecium,[2] covered with

[1] Slack's "Pond Life," p. 146. [2] *Paramecium aurelia.*

cilia, move about freely in all directions; the cilia are disposed in lines, and Ehrenberg counted sixty or seventy in some of the rows. They have been called "slipper animalcules," from their flattened form. Some interest attaches to these infusoria from the fact that small dark crystalline bodies have been seen in the frontal region; the real character and functions of which do not appear, as yet, to have been satisfactorily determined.



TRACHELIUS.

Another common form in infusions is Trachelius,[1] also with a ciliated body and an elongated upper lip or proboscis, so that the animal is pear-shaped or club-shaped, the proboscis being represented by the stalk of the pear. The mouth is seated on one side at the base of the proboscis.

Very simple forms of infusoria abound in stagnant water, especially those called *Euglena*, and allied genera. The individuals are at times so numerous as to impart a green colour to the water. It is uncertain whether these creatures should really be associated with such more complex forms as we have described, and, indeed, whether they should be called infusoria at all. The creatures to which we allude more particularly are spindle-shaped,[2] if such a definite character can be given to animals which

[1] *Trachelius anas* and *Trachelius ovum*. [2] *Euglena viridis*.

are constantly in the habit of distorting themselves, sometimes shortening themselves nearly into a sphere, and anon lengthening themselves into a narrow cylinder. Nevertheless, vary as they may, the head is attenuated, and the tail pointed, and there is a long whip-like filament, twice as long as the body, which proceeds from the head. The whole creature is of a bright green, except the two extremities, which are colourless, and a single bright red eye-spot, which is seen most distinctly amidst the green. It is difficult to see the *flagellum* or whip-like filament, proceeding from the upper lip, unless the water is coloured. There is a supposed species which becomes blood-red when mature, but perhaps it is only a variety of the green one.

EUGLENA.

The same water which contains the very common *Euglena*, known to every microscopist, will also contain a few solitary individuals of another species which differs greatly in its habits and action. This latter loves to dwell alone, seldom two are to be seen in company; whereas the former is most sociable, and congregates by scores. Both are alike green, with a bright red eye-spot, but here their similarity ceases, at least in general external appearances. The sluggish *Euglena*, which is also the solitary one, remains nearly in the same spot, seemingly holding on by its tail, with the head-portion now moving in one direction and now in another. It is twice as long as its sociable cousin, but has a habit of contracting itself

to half its length, then lengthening again, but in all its motions so leech-like, so slow, that it seems difficult to believe in its bearing any relationship to the vivacious common species. If looked at carefully the body will be seen to be traversed by parallel lines of little warts or elevations, running longitudinally down the body rather obliquely; but when the creature contracts itself, these lines are still more oblique, and have a spiral appearance, hence its name.[1] During the slow gyrations and deliberate twistings of this species, which are very convenient for its examination, it will soon be discovered that its body is flattened, or at the least it has the capacity of flattening itself; but it does not revolve on its longitudinal axis, and scarcely removes out of its place.

Yet another and more spirited member of the same family is, it seems to us, found in every ditch. It is green, with a red eye-spot, and a flagellum or whip proceeding from the head, but seldom to be seen. This may be called "Leaflet Euglena."[2] It is just like a small green leaflet dropped from a pimpernel or some humble plant, into the water, and suffused with life. In shape it is almost that of a miniature codlin apple in outline, but flat as a leaf. As it floats about, it turns first on one side and then on the other, and as to its flounder-shape there is no room for doubt. Nevertheless, it has its upper side, for it does not reverse itself, and this upper side is convex, like a lens, whilst the lower surface has a very decided concave depression in the

[1] *Euglena spirogyra.* [2] *Euglena pleuronectes.*

centre. The tail is colourless, and quite half as long as the body. As if to carry out its similarity to a leaf, there are two or three lines, resembling veins, which rise from near the base of the tail and proceed along the surface of the body towards the eye-spot. Not uncommonly the empty skins of this species, retaining the original form, but without colour, will be seen in proximity to the living individuals. In size it is broader, but not so long, as the common Euglena, and does not move quite so rapidly through the water, but usually in a straight direction, as if in pursuit of urgent business. Another *Euglena* with a long cylindrical body,[1] smaller than the sluggish Euglena, and without longitudinal warted lines, crawls about solitarily amongst Confervæ and duck-weed. All these four kinds are far from uncommon.

One of the most lively and interesting little creatures to be found amongst Confervæ and other of the fresh-water Algæ, is the Infusorian to which the name of Coleps[2] has been given. We have often been greatly amused in watching the movements of this creature. In form it is not unlike a barrel, that is, it is a short cylinder, with blunt ends, about twice as long as its diameter; at the posterior extremity are three or four short spines near the centre. Along the surface are parallel lines of little warts running down the entire length, and furnished with cilia. These ribs are united by transverse lines, so as to form a kind of rectangular network. In the interior are often seen spheres of green or brown opaque

[1] *Euglena deses.* [2] *Coleps hirtus.*

matter, which roll about freely. The motion of these animals is very active, but steady and sustained, caused by innumerable vibratile cilia. As it moves, it continues to roll over and over on its longitudinal axis, the opaque spheres rolling in its interior. To all appearance this little animal consists wholly of the external network, the centre being as free as the interior of a Volvox. A dozen of these organisms rolling about at the same time across the field of the microscope form a very amusing object. Now and then a specimen will be seen with a part of the upper portion broken away, as if gnawed by a mouse, and yet the animal rolls on as happily as if no accident had befallen it. A still more interesting phenomenon may also present itself, which serves to illustrate the mode in which these animals increase themselves. Here and there will be seen, in company with the usual form, some individuals longer than the rest, but with both extremities tails, that is, with the spiny processes at both ends, and the centre constricted, as if tightly girt by an invisible cord. If watched, these double individuals lengthen more and more, until they become just as large, and resembling two individuals soldered together by the head, and at last separation takes place, and two Coleps swim away, each on his own account. In this case one Coleps has divided itself into two—a common mode of increase in the Infusoria, and to be seen equally in other species. We have observed in these dividing, and in the recently-divided individuals, that the upper portion, for at least one-third of the entire length, is destitute of warts or apparent cilia, which afterwards

become developed. It is curious to see these double animals floating about, now one end foremost, and now the other, with equal vigour, though rather more awkwardly, than do the single animals, and like them rolling, like tubs, as they progress.

Very common in water which has stood for some time, especially pond-water, containing water-weeds in decay, is an active vigorous Infusorian, darting about in all directions, turning sharply at right-angles as it goes; now going a little way in one direction, then turning sharply in another, and anon, rushing amongst the filaments of Algæ, never resting an instant, and meanwhile causing a strong vortex in the water around it. This is a *Stylonichia*, with a flat, nearly elliptical body, the sides nearly parallel, the front extremity truncate, and the lower extremity rounded. At the latter end three or four stiff-pointed spines project a little beyond the body. The under surface, especially near the front, is furnished with numerous, say from twelve to twenty, flexuous, moveable, pointed processes, not unlike legs, with a swollen base resembling ball-and-socket joints, and these processes are in constant activity. From the front, down one side, runs a row of cilia. When the creature turns on its side it is seen to be flattened, and then the flexuous processes still more resemble legs, as it pushes amongst the filaments of Confervæ, apparently walking amongst them or pushing them aside. So rapid are all the movements of this and of many others of its tribe, that it is by no means easy to obtain a correct knowledge of all its parts. How are the legs (if we may call them by this name) to be counted, when they are

ever in motion, and when before those on one side have been guessed at, the creature twists itself round, and is off again, far away, out of the field of the microscope? Of course if they are killed by the introduction of some fluid other than water, they become still enough, but then so transparent and delicate are they that all the organs seem at once absorbed, and we gaze on something which resembles a little drop of glycerine jelly, without legs, spines, cilia, anything but a few minute clusters of granules. It is truly a pursuit of knowledge under difficulties to make out the details of such an active little animal as a *Stylonichia.*

Not a whit less active is a rather shorter and broader oval, or almost rounded animal, sometimes found in company with the latter. This creature has a covering on one side, like a mussel with one shell, but the shell is as transparent as the thinnest of glass, and is sometimes scarcely to be seen. Processes like legs, constantly moving, cilia, and spines, are also present; but Euplotes[1] is at once distinguishable from any of the Stylonichia, by its rounded form, and its thin and delicate carapace. Its movements and habits, even to the trick of turning on its side, or floating on its back, much resemble the former erratic creature. We have had a dozen of these at the same moment, darting about, as if engaged in a quadrille, over the field of the microscope. One objection which is not uncommonly urged against these Infusorians, by pond-hunters, is—that they are so small.

[1] *Euplotes charon.*

It is quite true that with less than what is termed "a quarter-inch" objective, they are only moving specks, but, when magnified not less than three hundred diameters, they furnish an inexhaustible fund of amusement and instruction. There is really no practical difficulty in the examination of objects with such a "power," especially when transparent; and a microscopist at all worthy of the name would work just as well with that as with an "inch." An animal only the two hundred and fiftieth, or even the five-hundredth of an inch long, has its history and mystery, as great as that of a Hydra or Cristatella. All that is lacking is patience, with perseverance to trace it out.

Whilst we are digressing, a complete shoal of little Infusorians are passing before our eyes which are not one-third the length of Euplotes. They are somewhat elliptical, little, transparent bodies, rather pointed at each end, and covered with long cilia, which give them their rapid movements. There is no other of the common forms which has a motion like this small Ptyxidium.[1] It rests perfectly motionless for an instant, then darts rapidly for a short distance in a straight line; then it rests again, and its long cilia are seen moving slowly; in an instant it darts in another direction, and as suddenly stops. Its whole career is a succession of jerks. Before we had discovered the name it was entitled to, we named this little fellow the "jerker," and it is by no means an inappropriate name. They abound in stagnant water

[1] *Ptyxidium ovulum.*

and in infusions, and may be traced through all the stages of self-division. Nearly perfect, and ready to part, a couple, joined end to end, may be seen jerking amongst the rest as rapidly as any, and even at times a rapid jerk will part them, and each will jerk on, never to meet again. A small fragment of fresh-water Conferva, such as a *Zygnema*, in a drop of water will sometimes be accompanied by scores of "jerkers."

Here we must leave the Infusoria and the whole of the Protozoa, to which this chapter is devoted, not because we have exhausted them all, or even those most common or interesting, but because we have fulfilled our intention of exhibiting the characteristics of some of the principal members of the class in question, leaving the special introduction to each of the genera and species to devolve upon those who devote themselves as specialists to the full investigation of the different manifestations of animal and vegetable life in the various groups.[1]

After describing some of these objects in his own popular and agreeable style, a writer on the low forms of life thus concludes his memoir— "My thoughts wandered back to the time when all these strange phenomena, these evidences of the Creator's presence in every atom, were still concealed from the vulgar eye, and were known, more imperfectly even than at present, and only to a privileged few. And then they sought to penetrate into the future, and I

[1] For special information, see Greene's "Manual of the Protozoa."

could picture to myself the time when every workman at his bench would be able to recognise, in each fragment of the material that passes through his hands, an evidence of the Wise Power which controls his own operations, as well as those of nature. And when I drew a comparison between the life of one of my own race and that of a vorticella, I was surprised to find how many men there are who seem to take the animalcule for their model; whose birth, growth, nourishment, wanderings, and, finally, whose tranquil 'fixed' existence all resemble that of the little bell-flower animalcule? A sense of awe crept over me when I recollected that, sooner or later, we all sink to rest as does the vorticella or the volvox in its wintry stage; but gloriously above all these thoughts rose the knowledge of the fact that even these senseless, soulless beings, do not die, but that the germ retains its existence, and gives rise to fresh forms of grace and beauty.

"'Fair summer's bloom, and autumn's glow
In vain pale winter brave;
Nor youth, nor age, nor wisdom know
A ransom from the grave.

"'But morning dawns and spring revives,
And genial hours return;
So man's immortal soul survives,
And scorns the mouldering urn.'"

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[1] "Popular Science Review," vol. i., p. 157.

## CHAPTER VIII.

### HYDRAS.

THERE is an old story of the Greeks, in which we were interested in school-days, which narrates that there was a celebrated monster, to which the name of Hydra was given, which infested the neighbourhood of Lake Lerna. It had a hundred heads, according to Diodorus, and as soon as one was cut off two immediately grew up unless the wound was cauterized. It was one of the labours of Hercules to destroy this monster, which he accomplished.

The modern hydra probably obtained its name from this fable, but it was quite a different sort of animal, although at one time its story created as much excitement in the scientific world as that of the monster Hydra could have done amongst the Greeks. The little animals to which this name is applied are solely the inhabitants of fresh water, and are common enough in ponds and ditches, adhering to aquatic plants. If we take a tuft of the water-crowfoot, or some other of the plants enumerated in our second chapter, and place it in a vessel of water exposed to the light, it is most probable that in half-an-hour we shall be able to see the hydra in its native element. No pocket-lens will be required to discover it, since it sometimes attains nearly an inch in length, but as

the species most likely to be first observed is a green one, nearly the colour of the plants to which it is attached, some little care will be required in looking for it until its form has become familiar.

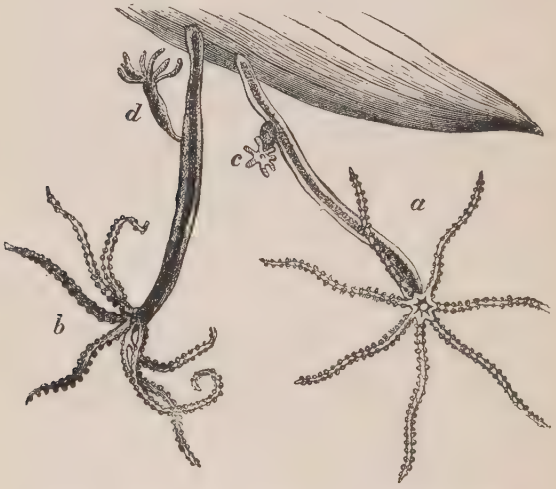
After a little patient waiting, several of these little creatures will be seen in different positions scattered over the pond-weeds; its body narrow and elongated, of a cylindrical shape, attached by its base to the plant; the outer extremity divided into six or eight long slender arms or tentacles, radiating from the body like a star, moving up and down and in all directions, and then retracting, until the whole animal seems to be only a lump of green jelly; then in an instant all is activity again. Such a creature is the Green Hydra[1] upon first acquaintance.

This little animal and all its operations may be watched in a glass vessel with the unaided eye. It is of a gelatinous nature, varying in colour according to species, but in the green hydra it is of a grass-green. The lower extremity of the body is expanded a little in the form of a sucker, by means of which it attaches itself at will; the upper or free extremity is furnished with a mouth, around which the contractile arms or tentacles diverge to the number of six to ten. These tentacles are little hollow tubes closed at the end, and the body is in like manner a hollow cylinder, with an opening for a mouth at the upper end. The whole surface of the body and tentacles is covered with minute warts or elevations, which enclose what are called "thread cells," containing the curious

*Hydra viridis.*

urticating bodies, supposed to possess the power of stinging.

They are voracious animals, feeding on water-fleas and such small creatures as the water contains, which are forced into the cavity of the body, digested, as far




GREEN HYDRA.—*a b*, mature; *c d*, budding young.

as possible, and the indigestible portion expelled. Large animals, such as a worm, are sometimes caught within the embrace of the hydra's tentacles, and it happens not unfrequently that one or two of the tentacles are broken off in the struggle, but in the end the hydra usually succeeds, and the captive descends into its distensible stomach. It is still an open question whether the little spines which are concealed in

the "thread cells" scattered over the hydra's body are stings. Some assert that when an attack is made these bodies are hurled at the prey, and have the power of benumbing it, so that it falls a ready victim. Others deny this stinging power.[1]

"'Tis a fine entertainment," writes Baker, "to behold the dexterity of a polype in the mastering its prey, and observe with what art it evades and overcomes the superior strength or agility thereof. Many times, by way of experiment, I have put a large worm in the very extremity of a single arm, which was instantly fastened on it with its little invisible claspers. Then it has afforded me inexpressible pleasure to see the polype poising and balancing the worm, with no less seeming caution and judgment than a skilful angler shows when he perceives a heavy fish at the end of a single hair line, and fears it should break away. Contracting the arm that holds it by very slow degrees, he brings it within the reach of his other arms, which eagerly clasping round it, and the danger of losing it being over, all the former caution and gentleness are laid aside, and it is pulled to the polype's mouth with a surprising violence."[2]

The hydra is mostly celebrated for its marvellous powers of reproduction. This is in the ordinary way achieved by budding from any part of the body, except the tentacles. Sometimes two or three are proceeding at one time from the same individual. A little tubercle rises on the body of the parent, this

[1] See Lewes, "Sea-side Studies," p. 142.
[2] Baker, "History of the Polype," p. 65.

enlarges every hour, lengthens, and ultimately tentacles appear at the apex; but no sooner are the young thus furnished than they commence catching prey on their own account, whilst still attached to the body of their mother.

"It is not unusual to behold the young one and the old one struggling for, and gorging, different ends of the same worm together. In the summer months the young are budded after the rate of twenty in a month; and buds have been seen to develope on the bodies of the young ones, whilst still attached to their parent. The second mode of reproduction takes place in the winter, in the ordinary way, from eggs. The third is an accidental mode, but the most curious of all.

"If the body is halved in any direction, each half in a short time grows up a perfect hydra; if it is cut into four or eight, or even minced into forty pieces, each continues alive, and developes a new animal, which is itself capable of being multiplied in the same extraordinary manner. If the section is made lengthwise, so as to divide the body into two or more slips, connected merely by the tail, they are speedily resoldered, like some heroes of fairy tale, into one perfect whole; or if the pieces are kept asunder each will become a polyp; and thus we may have two or several polypes with only one tail between them; but if the sections be made in a contrary direction—from the tail towards the tentacles—you produce a monster with two or more bodies and one head. If the tentacles—the organs by which they take their prey, and on which their existence might seem to depend—are

cut away, they are reproduced, and the lopt-off parts remain not long without a new body. If only two or three tentacles are embraced in the section, the result is the same, and a single tentacle will serve for the evolution of a complete creature. When a piece is cut out of the body, the wound speedily heals, and, as if excited by the stimulus of the knife, young polypes sprout from the wound more abundantly and in preference to unscarred parts; when a polype is introduced by the tail into another's body, the two unite and form one individual; and when a head is lopt off, it may safely be engrafted on the body of any other which may chance to want one. You may slit the animal up, and lay it out flat like a membrane, with impunity; nay, it may be turned outside in, so that the stomach surface shall become the epidermis, and yet continue to live and enjoy itself. And the creature even suffers very little by these apparently cruel operations—

> 'Scarce seems to feel, or know
> His wound,'

for, before the lapse of many minutes, the upper half of a cross section will expand its tentacles and catch prey as usual; and the two portions of a longitudinal division will, after an hour or two, take food and retain it."[1]

It is scarcely to be wondered at that, when these curious facts were first made known, the scientific world was amazed, and popular writers turned them into ridicule. The leading men of the learned

[1] Johnston, "British Zoophytes," vol i. p. 135.

societies were daily experimenting on these poor creatures, and transmitting them to one another from distant countries by careful posts, and as most precious gifts, and even ambassadors interested themselves in sending early intelligence of the engrossing theme to their respective courts.

Besides the above-named green species, which has the tentacles rather shorter than the body, there is an orange-brown hydra,[1] common enough round London, with more slender tentacles, longer than the body, and numbering from seven to twelve.

The third species is brown,[2] the lower part of the body suddenly attenuated into a kind of stalk. The tentacles are from six to eight, very long and thin, extending to several times the length of the body. In some localities this seems to be as common as the green one. All are found under similar conditions, and in the same places, so that it is by no means unusual to find them mixed together in the same gathering. There is no difficulty whatever in preserving them alive in jars of water containing aquatic plants, to which water-fleas and other minute animals may be added as food. The hydra is capable of going without food for some time, weeks it is said, growing thin meanwhile, but still active. They need not be put to such inconvenience, for small shreds of fresh meat will always be welcome in the absence of living prey. None of the experiments to which we have alluded need repetition: they have all been demonstrated and confirmed, and the poor

[1] *Hydra vulgaris.* [2] *Hydra fusca.*

hydras should now be permitted to enjoy life in peace.

Marine animals of the Hydra type are extremely common all around our coasts, and are cast up by every tide; but in these instances a number of animals are found living in community within their horny and branched cells, attached to each other in the form of corallines, or like a tuft of seaweed, and commonly known by the name of zoophytes. Only one of these community-loving, or sociable hydra, is to be found in fresh water, and that so rarely that it need only to be named as an example of the sociable habits of some species, but without any hope that the majority of our readers will ever have the good fortune to meet with it.

This Cordylophora[1] is branched and plant-like, between two and three inches high, very slender, and branched in a zigzag manner, with short opposite branches. The polyps emerge from orifices at the ends of the branches, each head with from twelve to fourteen delicate tentacles like gossamer threads waving in the water.

CORDYLOPHORA.

It was first found at Dublin, in the water of the Grand Canal,

[1] *Cordylophora lacustris.*

attached to an old boat. It has since been found in some of the London docks, on a piece of an old boat at Tipton, on an old boat in the Stourbridge Canal, in a cistern at Kensington, and at King's Lynn.

Few in number as are the species of fresh-water hydra, they may be taken as the representatives of the class *Hydrozoa*, and in some sense of its allied class, the *Actinozoa*. These scientific names convey but little meaning to the uninitiated, but when we name some of the animals included in both, it will be seen what relationships belong to our little hydra, and how respectable are its family connections. The former class has not only the zoophytes of the sea-shore for its members, but also the curious Medusa and Jelly-fish; and the latter includes not only the Sea-anemones, but also the tiny builders of the coral-reefs, with a history running backwards through fossil-corals to the remote Silurian age.

"And catching prey on every side, with feelers
Countless as sunbeams, slight as gossamer;
Ere long transfigured, each fine film became
An independent creature, self-employ'd,
Yet but an agent in one common work,
The sum of all their individual labours.
Shapeless they seemed, but endless shapes assumed;
Elongated like worms, they writhed and shrunk
Their tortuous bodies to grotesque dimensions;
Compress'd like wedges, radiated like stars,
Branching like sea-weed, whirl'd in dazzling rings;
Subtle and variable as flickering flames,
Sight could not trace their evanescent changes,
Nor comprehend their motions, till minute

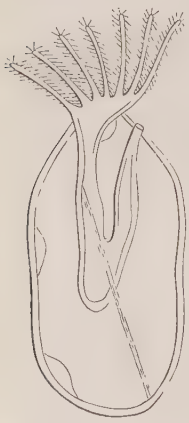
And curious observation caught the clue
To this live labyrinth —where every one,
By instinct taught, perform'd its little task :
To build its dwelling and its sepulchre." [1]

[1] Montgomery's "Pelican Island."

## CHAPTER IX.

### FRESH-WATER POLYZOA.

No account of the inhabitants of still waters could be considered complete which did not make some allusion to those animals which are the pride of the pond-collector, and known generally by the name of Polyzoa. This kind of animal prevails largely in salt waters, but the fresh-water representatives are wholly distinct as species, and are considered as a group which may be studied without particular reference to their marine relatives. The general character or type of a Polyzoon is admirably summed up by Professor Allman in the fewest words :—"Let us imagine an alimentary canal, consisting of œsophagus, stomach, and intestine, to be furnished at its origin with long ciliated tentacula, and to have a single nervous ganglion situated on one side of the œsophagus. Let us now suppose this canal to be bent back upon itself towards the side of the ganglion so as to approximate the termination to the origin. Further, let us imagine the digestive tube



TYPICAL POLYZOON.

thus constituted to be suspended in a fluid contained in a membranous sac with two openings, one for the mouth, and the other for the vent, the tentacles alone being external to the sac. Let us still further suppose the alimentary tube, by means of a system of muscles, to admit of being retracted or protruded according to the will of the animal, the retraction being accompanied by an invagination of the sac so as partially or entirely to include the oral tentacles within it, and if to these characters we add the presence of true sexual organs occupying some portion of the interior of the sac, and the negative character of the absence of all vestige of a heart, we shall have perhaps as correct an idea as can be conveyed, of the essential structure of a Polyzoon in its simplest and most generalized condition."[1]

Some of these animals delight in sub-alpine lakes or rapid rivulets, where they adhere closely to the under-surface of stones, while others prefer slow rivers or the still waters of canals and ponds. One species has been found as deep as four feet in the water, but usually they occur at much less depths, and frequently at the very surface, attached to the under-side of the leaves of floating plants. With one exception they are destitute of locomotion, being permanently attached to some fixed object; and all, with this solitary exception, impatient of the light, withdrawing as much as possible to the most shaded and gloomy spots.

This is the barest skeleton of the character of the

[1] Allman, "Fresh-water Polyzoa," p. 7.

fresh-water Polyzoa, to fill up the details of which there is ample material in the excellent volumes which have been published on the subject, but even an abstract of which would go far to fill our little volume. The best substitute we can offer is to indicate the animals themselves, so that by collecting and studying them our readers may compensate for our deficiencies.

We have said that with but one exception these creatures were permanently attached; and this one exception of a travelling Polyzoon we have in the Cristatella,[1] which creeps over the stems and leaves of aquatic plants, in clear ponds, delighting to bask in the sunlight.

The moving Cristatella is an entire colony, and not a single individual, the Polyzoa being of very sociable habits; and this colony is united together into a body of an oval shape, rounded above, and flattened below, temporarily adhering by means of the under surface. On the upper, rounded surface, are the openings through which the crests of the Polyps emerge, and these are arranged in three regular lines around the margin, with a clear space in the centre. In the centre of the under-side is a disc, corresponding to a foot, by means of which the colony is moved or moored.

Usually these colonies are not more than from half-an-inch to an inch in length, although they have been known to attain two inches, with a width of about one-eighth of the length. It is a splendid object to contemplate when in full expanse, the head

[1] *Cristatella mucedo.*

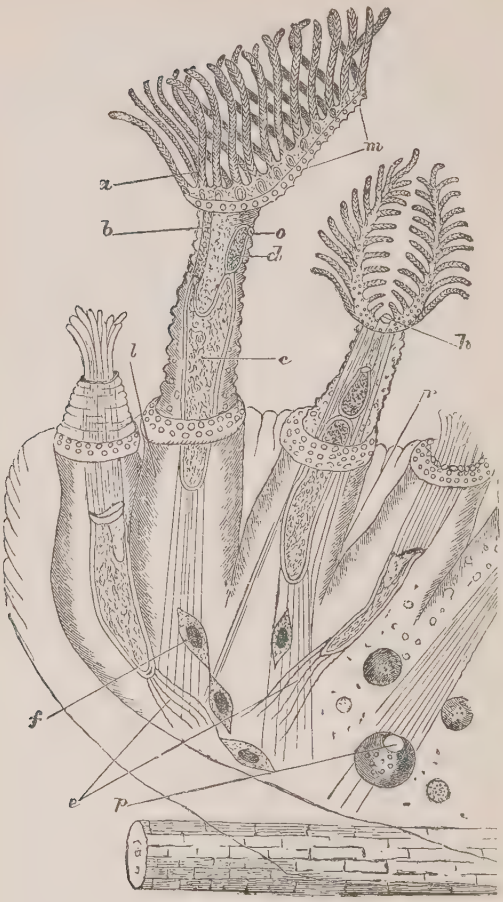
of tentacles thrust out at every opening, and shining in the sun. Contrary to the usual habit of these animals, the Cristatella appears to love to thrust out and display its tentacles, and if momentarily disturbed it retracts them, only to thrust them out again as soon as the danger is past.

The crown of tentacles which is thrust from the openings in the fresh-water species has nearly the form of a horse-shoe, from which the tentacles arise, but in marine species the form is usually circular. Each tentacle is a closed tube with a row of moveable cilia along each side, vibrating towards the apex on one side, and towards the base on the other. These tentacles are about eighty in number in Cristatella, being more numerous than in any other British species.

Singular bodies are at some seasons of the year found associated with the Polyzoa, which have been called *statoblasts;* although at one time erroneously supposed to be eggs, they are really a kind of reproductive buds. They are oval or round-flattened bodies, with a horny shell, often covered with spines, but sometimes naked, which at length open, and permit of the escape of a young Polyzoon. In Cristatella the statoblasts are scarcely one-thirtieth of an inch in diameter, circular in outline, and surrounded by a fringe of slender spines, double-hooked at their extremities.

Another British species is Lophopus,[1] which has been the longest known of any species in this country, and was figured under the name of "Bell-flower

[1] *Lophopus crystallinus.*




LOPHOPUS.

*a h*, mouth ; *b*, œsophagus ; *c*, stomach ; *d*, intestine ; *e*, muscles ; *f*, statoblast ; *m*, lophophore ; *o*, vent ; *p*, parasite.

Animal" one hundred and thirty years ago.[1] It occurs in ponds and ditches attached to duckweed, burrweed, and other aquatic plants, but avoiding as much as possible direct sunlight. Although easily detached from its support it has no power of locomotion, and being one of the largest of the Polyzoa, is the one most easily studied. Johnston says that it occurs in stagnant waters, "especially such as are tinctured with iron in solution," being chiefly developed in the autumn.

"They dwell together," wrote Baker, "from the number of ten to fifteen in a filmy kind of mucilaginous or gelatinous case, which, out of the water has no determined form, appearing like a lump of slime, but when expanded therein resembles nearly the figure of a bell with the mouth upwards; and is usually about the length of half-an-inch, and a quarter of an inch in breadth or diameter. This case is very transparent: all the motions of its inhabitants may be discerned through it distinctly. The bells or colonies are to be found adhering to the large leaves of duckweed and other aquatic plants; and may easiest be discovered by letting a quantity of water with duckweed in it stand quietly for three or four hours in glass vessels, in some window or other place where a strong light comes, for then, if any are about the duckweed, they will be found on careful inspection extending themselves out of their cases, spreading their plumes, and making an elegant appearance."

Mr. James Fullager, to whom we are indebted for

[1] Baker, "Employment for the Microscope," p. 306, pl. 12.

our illustration, has thus described the animal, with reference to the wood-cut, the letters referring to the parts under description.

This large Polyzoon is a most interesting object for the microscope, and being transparent, is very available for examination, as the formation of the statoblasts (*f*) can be seen in different stages of growth, from their first appearance as a little swelling, when they are quite colourless, to their perfect form, when they become detached and fall free in the perigastric space (*l*), having become gradually coloured, the centre of a dark brown, and the margin a rich yellow. The process of their propagation by gemmation or budding, by which young ones are added to the existing colony of living Polyzoa, can be plainly seen; while the statoblasts (*f*) are designed to propagate the species in the following spring, and are liberated from the Polyzoon at its death, when the transparent sac is decomposed, and the statoblast escapes and sinks to the bottom of the water.

The perfect transparency also enables us to witness the internal operations of their system. The action of the stomach in the process of digestion can be observed with great clearness. The contents are seen at times to consist of small desmids, and other disc-shaped and globular bodies, together with decayed vegetable matter, &c. The action of cilia on the expanded tentacles causes a current of water to set in towards the mouth (*a*, *h*) bringing with it the food required; and if in the vortex thus formed there should be any large and objectionable pieces, they are prevented from entering the mouth by a quick

lashing motion of the tentacles, which rejects and throws them out of the reach of the vortex. The accepted morsel passes directly into the œsophagus (*b*), from thence into the stomach (*c*), where it is digested by the up-and-down motion of a contracting and expanding nature of that organ. The lower part of the stomach at intervals is seen to be contracted somewhat in the shape of an hour-glass, in which for a moment part of the contents of the stomach are retained, and then again released to mix with the rest. After being subjected to the action of the stomach for some time, the alimentary matter is delivered by degrees into the intestine (*d*), from whence it is expelled through the vent (*o*), in the form of oval or egg-shaped pellets.

The perigastric space (*l*), is filled with a clear fluid, which also extends up the lophophore (*m*). By the movement of these bodies it is evident that there is a constant rotating motion in this transparent fluid, by which these particles are kept in a perpetual whirl from one part to the other, and at times with great rapidity. No doubt this motion is produced by vibratile cilia on the interior of the body, though not observable. In some of the colonies of the *Lophopus* there are a number of globular bodies, varying in size, up to that of an ordinary Volvox. These bodies are considered to be parasitical, as they do not appear to have any necessary connection with the economy of the Polyzoon in whose interior they occur. This would appear to be the case from the fact that in some colonies not one of them is to be seen, while in others they are very numerous.

In one instance of a colony under my observation they were increased in such numbers of all sizes that they entirely filled the perigastric space (*l*), forcing the smaller particles up even into the lophophore (*m*), and ultimately bursting the whole colony, and escaping into the water, when all motion in them ceased, and they soon disappeared altogether. When they are few in number and of various sizes in the animal, they form a novel and pleasing sight as they are carried up and down by the current in the perigastric space ; at times revolving with great rapidity on their own axis, and at the same time round one another. Frequently a group of five or six may be seen revolving together. Some of them are perfectly clear, others are partially covered with small globular forms of a brighter appearance than the globe itself. The largest of them are sometimes marked with irregular patches of various shapes, and, as they revolve on their axes, it gives them the appearance of a miniature world. A few show an opening (*p*), by which they are seen to be empty hollow globes, but what they really are is not known.

On being alarmed the *Lophopus* quickly retracts within the transparent cell, and again protrudes when all is quiet, unfolding its beautiful crown of tentacles, in the course of which movement the action of the muscles (*e*) is plainly seen. The expanding of the tentacles immediately on the protrusion of the polypide from its cell is one of the most pleasing sights that can be presented to the observer, as the cilia with which they are studded are instantly in full play, passing up on one side of the tentacle from the base

to the tip, and down the opposite side, like an endless chain, thereby forming the vortices in the water by which the particles of food are brought to the mouth. Sometimes the colony consists of from six to twelve polyps, and will divide into two colonies, commencing the division at *r*, and slowly separating down to the point where it is fixed to the plant, each part moving in opposite directions. They then propagate by gemmation or budding. This process is very interesting to watch, from the first appearance in the parent, to the issuing of the young from the newly-formed cell. When the minute tentacles of the young are exerted, they form a beautiful contrast to the fully developed tentacles of their parents. Though small, yet the same functions are visible in relation to digestion, &c., as in the older ones.[1]

Transparent as these creatures are, they are covered by a still more transparent envelope, which might escape observation unless some extraneous objects happened to be attached to it, as is often the case. The muscles of the creature when the polyp is fully extended may be seen drawn tight, and have the appearance of fine glass threads. When the animal is retracted within its cell, the muscles (*e*) are relaxed and bent.

Fortunately these colonies may be collected, and preserved in active and vigorous life, so as to be continually under observation day by day for months, if moderate care be exercised as to water supply, and the maintenance of natural conditions.

Of Alcyonella, three species have occurred in

[1] "Science-Gossip," 1874, p. 270.

Britain, but only one is at all common.[1] It has been found abundantly in the Regent's Canal, and other canals, and in the London docks attached to floating timber. It seeks obscure places, and attaches itself to stones, timber, and submerged branches, in stagnant and slow-running water. The brown fungus-like masses sometimes weigh upwards of a pound, of a very irregular lobed shape, surrounding the twigs and branches to which they may be attached.

"When a living specimen is examined in the water, its whole surface seems covered with a whitish down, which a slight examination shows to be occasioned by the protrusion of innumerable polypides; when removed from the water the polyps shrink back into their cells, and the surface then seems covered with a gelatinous investment, caused by the soft, papilla-like extremities of the tubes. These extremities contract no adhesion to one another, like the rest of the tubes, and the ectocyst, as it passes over them, becomes very delicate and transparent; in dead specimens they shrivel up and disappear, and then the surface of the mass presents a multitude of closely-applied hexagonal or pentagonal orifices. The whole production now assumes the appearance of a spongy, honeycomb-like mass, and this has not unfrequently been mistaken for a fresh-water sponge. A vertical section shows it to be composed of a vast number of tough, horny-membranous branched tubes, closely adherent to one another, and each opening on the surface by one of the angular orifices just mentioned. Imperfect transverse septa may be seen at the origin

[1] *Alcyonella fungosa*

of many of the branches. The tubes, towards the end of summer, are loaded with mature statoblasts, which escape in great numbers into the surrounding water."[1]

The general appearance of the polyp masses of Alcyonella, when drawn out of the water, are so uninviting, if not repulsive, that we can scarcely wonder at their being so little known, or their interesting features so faintly recognised.

No less than ten species of *Plumatella* have at different times been found in the British Isles, but of these it will suffice to mention one, which might be called the Common Plumatella,[2] as a type of the rest. It is found on the surface of stones, turned away from the light, in streams, and on the underside of floating leaves in ponds. The size is variable, and Professor Allman says that he has seen it radiating over a space of upwards of twelve square inches on a flat stone, and of one variety with branches three inches in length. Unlike the forms above described, this does not assume compact masses, but the dwelling of the colony, in its ordinary form, creeps over the object to which it is attached, in a branched, confervoid manner, radiating from a common centre. Perhaps no Polyzoon is more variable than this, but in all it is beautiful. In some places it is very abundant, and is generally distributed throughout England. The openings are placed at intervals along the principal branches, singly, or occasionally in twos or threes, and from these the feathery crests of the Plumatella emerge when the animal is

[1] Allman, p. 89.

[2] *Plumatella repens.*

PLUMATELLA.

perfectly undisturbed, but it is peculiarly timid, and the crests are immediately withdrawn upon the slightest disturbance. In the *variety* of this Plumatella, which some have considered as a distinct species, instead of the branches of the polypidom creeping along on the surface of the plant, to which they are more or less attached, they are quite free, and form a somewhat entangled bush-tuft; the essential characteristics of the enclosed animal is alike in both. The number of tentacles in each crest of the common Plumatella is sixty, but in some of the other species it is as low as forty. In structure and movements they correspond with the other fresh-water polyzoa.

Fredericella[1] is another of the branched tubular polyzoa, with the branches distinct from one another, and the openings terminal at the ends of the branches. This seems to be particularly attached to canals, having been found plentifully in the Regent's Canal at London, in the Grand Canal, Dublin, and in the Union Canal, Edinburgh. It is attached to submerged stones and the leaves of aquatic plants, preferring shady situations. This is one of the most widely distributed of the fresh-water polyzoa, having been met with abundantly in the three kingdoms. The Polypidum is partly attached and partly free, the adhering portion often extending for several inches, and sending off numerous free branches an inch in height. It is rather horny, and of a brownish colour. The crown is rather more orbicular than usual, and the number of tentacles twenty-four, which, when expanded, form a bell-shaped crest. Professor Allman says of this species,—"I have met with it during the whole of the spring, summer, and autumn months, both in standing waters and rivers, generally avoiding direct exposure to the daylight, though not so decidedly a lover of obscurity as several other species. The tentacular plume is, even

FREDERICELLA.

[1] *Fredericella sultana.*

to the naked eye, an object of extreme elegance, and we can easily participate in the feelings which must have actuated Blumenbach when he bestowed on this little animal the imperial designation it has since borne. It can be kept alive and healthy in a pail of pure water, and when undisturbed the polypides will readily issue from their cells, and display their plumy crowns. A large branch thus studded with the campanulate crests of the polypides is an object which, in elegance, can hardly be surpassed, and with these strange sentient flowers instantly retreating on the approach of danger, and, when all is once more quiet, again coming forward in their beauty, presents a spectacle not easily forgotten."[1]

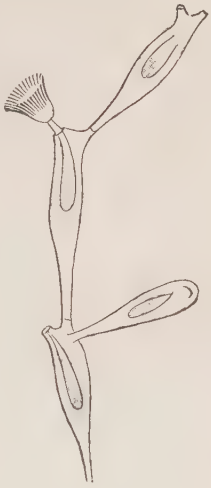
The Paludicella[2] bears some resemblance to a creeping coralline, running over submerged stones to the extent of one or two inches, giving off straight, rigid branches, either singly or in pairs; every branch, and portion of adherent trunk consists of club-shaped joints attached end to end, so as to present a chain-like appearance. The openings are on one side, near the wider ends of the club-shaped joints, and terminate in small tubes which project from the joints. The colour of the polypidum, when old, is dark brown.

The crown is circular, from which arise the sixteen tentacles, in a perfectly funnel shape. In all its features there is such a manifest distinction between the Paludicella and all the other fresh-water forms, that there is scarcely a possibility of mistaking it.

[1] Allman, p. 112.

[2] *Paludicella Ehrenbergii.*

The animal is very timid, and it may be observed for hours before it ventures to protrude from its cell, and then it is often visible only for a few seconds at a time. It is so great a lover of obscurity that it has only been found in situations that are not exposed to direct daylight; the finest and most luxuriant specimens having been obtained beneath the arches of viaducts on the Grand Canal at Dublin, and in similar situations elsewhere. It is most abundant during summer and autumn.



PALUDICELLA.

There seems to be very little doubt that these beautiful microscopical animals are by no means so plentiful around London as they were some few years ago. It is not improbable that the increased popularity of the microscope, Saturday half-holidays, and the excursions of microscopical and natural history societies have combined to produce this result. Let us hope that in their destruction they have left some salutary lessons behind them.

## CHAPTER X.

### ROTIFERS.

The older naturalists recognised amongst aquatic animals a group of singular creatures, which appeared to them to differ from all others, in bearing about their heads or upper extremities certain organs, constantly in motion, and resembling wheels. These they called "wheel-animalcules." The modern name of Rotifera perpetuates the old romance of "wheel-bearers," and yet the organs in question are not wheels, but simple expanded discs, varying in form according to the species, having the margin fringed with one or more rows of delicate hairs, which, by their continual and successive motion around the disc, certainly had the appearance of rapidly-revolving wheels. The conceit is dead, but the animals still survive, and we have as inhabitants of ponds and ditches, as well as of slow-running streams, and a few marine, a great number and variety of Rotifers, which seem to bear a wheel at their heads. This little group has been a great puzzle to the systematists, and even to this day there is no unanimity amongst them as to the precise place in creation which the "wheel-bearers" should occupy. Some say that they link with the shrimps and lobsters, others with the worms. This uncertainty will in no

way influence our operations, and we shall proceed to indicate what sort of creatures these Rotifers are, some of the places in which they love to dwell, and what the interest they possess for the rambler in search of the notable things in the water.

Converse for half-an-hour with any one of the somewhat numerous class of enthusiasts who spend their Saturday afternoons in exploring ponds and ditches, and you will not fail to hear something of *Stephanoceros*.[1] And who is *Stephanoceros?* We must confess that it is only a Rotifer with a big name, but a splendid one it must be confessed, and hence the ambition of every

THE CROWN ANIMALCULE.

[1] *Stephanoceros Eichhornii.*

fresh-pond hunter is to find *Stephanoceros*, or, as it has been called, the "Crown Animalcule." Ask a party of Quekett Club excursionists, starting for a trip to the ponds, what they expect to find, and the answer will be Stephanoceros. Turn over the leaves of any volume professing to be a guide to the microscopist, and amongst desirable animals you will find mention of Stephanoceros. Unfortunately, this is a rather erratic individual, and where found plentifully in a pond during one year not a single one may be found in the next. Let us attempt its portrait.

The creature reaches a length of one-fifteenth of an inch, and therefore is distinctly visible to the naked eye. In its adult condition it becomes permanently fixed on aquatic plants. The lower portion, which is attached, consists of a gelatinous envelope, like a transparent cylindrical case, into which the animal can retract itself at will. When expanded, the upper portion which protrudes from the case is terminated by five spreading arms, and these are furnished throughout with long hairs, or cilia, which almost imperceptibly produce waves of motion from end to end. These expanded arms, with their cilia, form a kind of network cup, in the centre of which, at the bottom, is the mouth. "There is a manifest vortex in the enclosed area, for small infusoria approaching are presently drawn in and are driven about in the space. They can enter readily at all parts between the arms, but cannot get out; for if one approaches the arms from within, it is seen instantly to be shot back towards the centre. I perceived," writes Mr. Gosse, "after some careful watching, that

the motion was caused by the *setæ*, a minute tremulous, and, as it were, spasmodic wave, being seen to run along the nearest pencils at the instant. It is clear, then, that the *setæ*, crossing each other, serve as a living net, which admits the prey to enter without resistance, but, if touched from within, vibrates in such a way as to jerk the touching body with considerable force towards the centre of the contained area. When once the prey passes down below the area into the mouth-funnel, which is formed by very contractile walls, a slight constriction takes place in the neck, which has the effect of forcing the monad down to the mouth of a capacious crop which lies all across the upper part of the body. Here a sort of swallowing motion is seen, and the prey passes with a gulp down into the cavity."[1]

The lower part of the body is prolonged into a slender foot which passes through the centre, or, rather, is surrounded by the transparent envelope, and is attached to the object on which the Stephanoceros has fixed itself. The slender foliage of the water milfoil[2] is a favourite home of this species, but it has been found on other plants, and on the slender roots of the willows which run into the water. It is considered a voracious feeder, and will swallow scores of infusoria, one after the other. When found, it should be taken home, carefully attached to the plant on which it was gathered (of course in a bottle of water), and may be kept alive for some time in

[1] "Popular Science Review," vol. i., p. 34. [2] *Myriophyllum.*

jars of water exposed to the light, but guarded from the hot rays of the sun. Fragments of fresh-water plants may be occasionally added, but these need not be rooted; and in this manner the strange creature may be kept five or six weeks, and afford continual instruction and amusement.

Similar, but yet different, is another of the large rotifers which become permanently attached to aquatic plants. This is the Floscularia;[1] it may be one of two or three species, but the general appearance and habits of all are the same. Like the Stephanoceros this has also a delicate thin transparent envelope surrounding the lower portion of the body and the foot. So delicate is this membrane that it is often to be seen only with the greatest difficulty. The principal difference which will become manifest is that the lobes or arms are very short and knobbed at the end. The long cilia are clustered upon these knobs, from which they radiate in all directions. The animal is smaller than the Stephanoceros, but many consider it even more beautiful. The number of lobes is five, and of the long cilia which beset each lobe from forty to fifty have been counted on each knob. When the Floscule draws itself into its case, all the cilia are thrown upwards in the same direction, parallel to each other, so as to form a single pencil. "They are motionless when expanded, but, while protruding, and in the instant of expanding, the pencil is seen to be agitated with a close and rapid thrill or wave, which runs along it, and looks

[1] *Floscularia ornata*, or *Floscularia cornuta*, see frontispiece.

much like the flickering of a candle-flame. It ceases the instant the disc is expanded."[1]

This creature will be met with on the leaves of submerged plants, such as the water crowfoot, but a little experience is necessary to distinguish them. Mr. Slack thus gives advice which will be found useful:—"When the floscules, or other tubiculous rotifers are specially sought for, the best way is to proceed to a pond where slender-leaved water-plants grow, and to examine a few branches at a time in a phial with a pocket lens. They are all large enough to be discerned in this manner, and as soon as one is found others may be expected, either in the same or in adjacent parts of the pond, for they are gregarious in their habits. With many, however, the first finding of a floscule will be an accident, as was the case last April, when a small piece of myriophyllum was placed in the live box, and looked over to see what it might contain. The first glimpse revealed an egg-shaped object, of a brownish tint, stretching itself upon a stalk, and showing some symptoms of hairs or cilia at its head. This was enough to indicate the nature of the creature, and to show the necessity for a careful management of the light, which being adjusted obliquely, gave quite a new character to the scene. The dirty brown hue disappeared, and was replaced by brilliant colours; while the hairs, instead of appearing few and short, were found to be extremely numerous, very long, and

[1] For a fully-detailed account of this animal, see also "Popular Science Review," vol. i., p. 160.

glistening like delicate threads of spun glass."[1] He then goes on to describe the floscule, but our space will not permit us to follow him.

The last of the fixed Rotifers to which we purpose alluding is the *Melicerta*,[2] and with this we are introduced to quite another type of tube-dwellers. So much has been written of the "tube-builders" that it is difficult to add anything, or even to describe them but by repetition; hence we cannot do better than quote one of Mr. Gosse's excellent descriptions. "Imagine, then, a little tube about 1-30th of an inch high, slightly widening at the top. It stands up from the surface of the leaf erect, being affixed by the base, which is sometimes dilated, the mouth being uppermost. This tube is of a dark yellowish or reddish-brown hue, and is found to be composed of a multitude of round pellets, set very regularly in a sort of mosaic, apparently agglutinated by a cement insoluble in water. But while we gaze, a curious object is slowly protruding from this tube. A complicated mass of transparent flesh appears, involved

MELICERTA.

[1] "Marvels of Pond Life."

[2] *Melicerta ringens* and other species.

in many folds, displaying at one side a pair of hooked spines, and on the other two slender truncate processes projecting horizontally. As it exposes itself more and more suddenly, two large rounded discs are expanded, around which, at the same instant, a wreath of cilia is seen performing its surprising motions. Often the animal contents itself with this degree of exposure, but sometimes it protrudes further, and displays two other smaller leaflets opposite to the former but in the same plane, margined with cilia in like manner. The appearance is now not unlike that of a flower of four unequal petals; from which resemblance, Linnæus, who compared it to a ringent labiate corolla, gave it the trivial name *ringens*, by which it is still known. On each petal we see a white line, probably a nervous thread, running parallel with the margin, to which it is connected by many radiating short lines.

"But the eye is involuntarily drawn from the petals themselves of this living flower to the beauty of the coursing cilia; these appear to chase each other in ceaseless race along the margin, running down and up the sinuous divisions of the petals; now relaxing, now refreshing, their speed. This progression of the ciliary waves is now well understood; but, while we gaze upon them, we find it easy to forgive the error of those who maintained that the teeth actually ran around the margin of the stationary wheel.

"Below the large petals, on the ventral aspect, and just above the level of the projecting antennæ, is a small circular disc or cavity, within the margin of which a rapid rotation goes on. This little organ I

can compare to nothing so well as to one of those circular ventilators which we sometimes see in one of the upper panes of a kitchen-window, running round and round, for the cure of smoky chimneys."[1] Then follows his excellent description of how he watched and saw the animal build up its tube, how the pellets were formed, and how they were deposited one by one, as they were made, on the upper portion of the tube. Thus a "home without hands" is constructed in a most marvellous manner by a diminutive creature supposed to occupy a place very low indeed, as compared with the bird and the beaver, in the scale of creation.

Like the Stephanoceros and the Floscule, this little architect must also be sought on the submerged leaves and stems of aquatic plants, such as the water milfoil. If one or two are found, the search should be continued at once, for, as they are gregarious, many more will doubtless follow. Gosse states that he has found as many as sixty or seventy upon a single leaf.

From individuals who live singly and separately, we pass to others flourishing in communities, of which two examples must suffice. One, formerly to be found in great quantity in little ponds on Hampstead-Heath, is the Conochilus.[2] The clusters are distinctly visible rolling slowly through the water, now rising, now falling, not by any sudden jerking, but gradually and steadily, like that of a large body impelled by a combination of small forces. The

[1] "Tenby," p. 313

[2] *Conochilus volvox.*

groups (not exceeding 1-30th of an inch in diameter) may consist of fifty or sixty individuals, attached together by the extremity of the slender foot to a common centre, from which they radiate in all directions, with the heads outwards. Each indi-

CONOCHILUS VOLVOX.

vidual is bell-shaped, and resembles a wine-glass, without its expanded foot. The disk is large, and of two semicircular portions, around which the cilia play in such active motion that the eye distinguishes no break in the circle.

"When a cluster is taken out of the phial in which it is swimming about, and put into the live-box, for examination under the microscope, the number of animals lying over each other, if it be populous, is confusing. The numerous feet radiating from the centre like the spokes of a glassy wheel, and the multitude of crystal bells around the circumference,

each surrounded by its crown of rapidly-rotating and strongly-marked cilia, are almost distracting. Some display the front, some the side; some turn themselves so as to present to the eye a transverse view of the crown, others are almost vertical; it is only in the latter, when the eye looks down upon the disc, that the divided structure can be seen. Some are continually shrinking up by forcible contractions of the foot, and some are vomiting forth the flattened pale-yellow eggs which are ready in the ovary. This is, indeed, the first thing done as soon as a cluster is put into the live-box, the animals being probably excited by being caught and moved from vessel to vessel. Many eggs are presently seen, forcibly expelled from different individuals, and whirling about in front of the animals."[1]

After an hour or two of confinement in the live-box, the animals will be seen to separate, and the communities break up. Each individual now floats about on its own account, with the foot shrunk up to the dimensions of a small nipple, and this end generally thrust foremost. This dissolution is but the prelude to an early death, the motions grow fainter and fainter, until they cease altogether, and nothing is left but a yellow indistinct spot to represent the once-vivacious Conochilus.

The other composite Rotifer is *Lacinularia*,[2] which is much less common, but sometimes to be found in numbers living amongst the Hornwort[3] in ponds and

[1] Gosse, "Contributions to the *Rotiferæ*."
[2] *Lacinularia socialis*. [3] *Ceratophyllum*.

streams, with a preference for the latter. The clusters are much larger than those of *Conochilus*, being as much as one-fifth of an inch in diameter. The individual animals have an elongated conical form, with the wide extremity outwards, and the narrow blunt end attached to the common centre. The outer extremity is terminated by a horse-shoe-shaped wheel organ or ciliated disc. When the animals are contracted and at rest, the disc is drawn in, and they have at that time a more pear-shaped appearance. There is one readily-appreciated difference between the habits of *Lacinularia* and *Conochilus*, that whereas the colonies of the latter usually float about freely in the water, those of the former, except in young colonies, are attached to aquatic plants. Unfortunately, confinement seems to be fatal to both, for, of the latter, Ehrenberg says :—" In vessels of water they rarely support themselves eight days ; they die and fall to the bottom, even if plants be growing with them."

The anatomy and physiology of the *Lacinularia* were closely investigated by Professor Huxley some quarter of a century ago, and the results are given in a most exhaustive paper on the subject, to which those desirous of more explicit information are referred.[1]

From the fixed and the community Rotifers we must now pass to the free and independent individuals, many of which are common in the localities within our jurisdiction. We shall not feel bound to restrict ourselves to any scientific order in their enumeration,

[1] "Transactions Microscopical Society," vol. i. (1853), p. 1.

but mention a few as examples of the rest. It would extend this chapter to disproportionate limits were we to attempt to describe all the Rotifers which may be found in still waters. Unfortunately there are no popular names by which these little creatures are known, so that we must be content with adopting the generic name.

The *Eosphora*[1] is a sprightly little species found in tiny pools on heaths and commons, as, for instance, on Hampstead Heath. Its body is cylindrical, about one hundredth of an inch in length, and a diameter of about one-third its length. Its two-toed foot is short, and of course occupies the lower end of the body, whilst the variable head is at the other. They will live and increase if placed in a little bottle of water, together with a few leaves of duckweed, some confervæ, or other aquatic plants, and left uncorked in full daylight, but protected from the rays of the sun. In this condition they will play about, darting through the water or scattering the sediment at the bottom, rotating slowly as they go. Small as they are, their movements may be watched with a pocket lens, if the fingers are placed on the opposite side so as to form a kind of dark background for the objects. When the animal is feeding, it rests upon its two-toed

EOSPHORA.

*Eosphora aurita.*

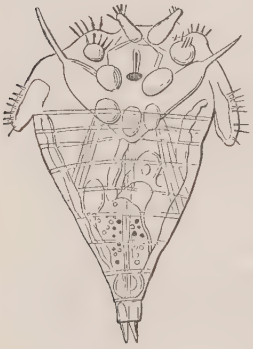
foot, the body is thrown forwards horizontally, and the front of the head is so oblique as to be brought almost as a flat surface into contact with the ground. Suddenly the animal ceases feeding, rears itself on its toes until it stands nearly erect, balances for a moment, then evolves from each side of its head, by a kind of turning inside out, a remarkable ear-like process, clothed with strong cilia. The action of these form vigorous circular vortices, of which the ear-like expansions are the centres, and in the same instant the animal shoots forward on its even course, revolving slowly as it goes.

Of *Notommata* there are several species, and two of these are to be found living within the rolling spheres of *Volvox*. One species persistently, the other occasionally, being thus parasitic. On examining the volvox, even with a pocket lens, the discoloured spots may be seen which indicate the presence of *Notommata*,[1] which lives and floats about inside the transparent sphere with as much ease and comfort as a goldfish in a glass globe. Sometimes, Mr. Gosse remarks that he has seen as many as four individuals inside one volvox, each pursuing its own vocation regardless of the others. Of the other species of *Notommata*, one is sometimes found in water-butts, another in water pools in bogs, and another in old infusions.

The *Synchæta* is compared to a boy's peg-top, with the iron toe driven in by constant "pegging" until only the point is visible. This point represents the

[1] *Notommata parasita.*

minute foot of the animal, with its tiny toes. "Now and then the creature rests on these united toe-tips, and rotates for several minutes, as if to maintain its character as a spinning top, then away it shoots, and glides swiftly and giddily through the clear water, by the hour together without repose, its enormous ciliary apparatus giving it great power of motion. The rounded front appears to be beset with cilia, but it forms a sort of indented crest or forehead, on which two antennæ are seated, as well as some pairs of curious stout branched bristles, which then descend on each side in the form of two hanging lobes or ears, richly clothed with vibrating cilia, and are powerful auxiliaries to swimming. As it swims it is almost continually contracting the enormous head with a sort of spasmodic twitching, which brings the ear-lobes momentarily to point forward, and alternately, and almost as quickly, recovering itself. The brilliant transparency of its tissues is highly characteristic of the tribe, and, combined with their elegant form and sprightly motions, makes them rank among the most charming representatives of the class."[1]



SYNCHÆTA.

[1] Gosse on Flexible Creepers, "Popular Science Review." vol. ii., p. 484.

Two species are found usually amongst *Confervæ*, but always in clear sparkling water, and one is only found in salt water.

The Pitcher Rotifers[1] are a numerous and very characteristic family, with a short, broad, urn-shaped body, and a long flexible foot. Some are absolutely marine, whilst others are inhabitants of ponds and ditches. Their principal feature is the pitcher-shaped lorica or shield of the body, which is notched at the top into several projections. The lorica has some resemblance to the shell of a tortoise, open at both ends; from the top an elegant wreath of cilia is protruded, and some slender spines. It has a capacious stomach, and an "aldermanic allowance of gizzard."

PITCHER ROTIFER or BRACHIONUS.

When the prey is caught within the circle of the vortex, caused by the action of the strong cilia, it is

[1] *Brachionus.*

speedily carried down to the gizzard, and occasionally, if found too large or unmanageable, is cast out again. "A description of this animal would be very incomplete if it omitted that important organ the tail (or foot), which in this family reaches the highest point of development. It is a powerful muscular organ, of great size in proportion to the animal, capable of complete retraction within the lorica, and of being everted wholly or partially at will. It terminates in two short conical toes, protruded from a tube-like sheath, and capable of adhering firmly even to a substance so slippery as glass. This organ may be observed to indicate a variety of emotions, if we can ascribe such feelings to a Rotifer, and it answers many purposes. Now we see it cautiously thrust forth, and turned this way and that, exploring like an elephant's trunk, and almost as flexible. Now it seizes firm hold of some substance, and anchors its proprietor hard and fast. A few moments afterwards it lashes out right and left with fury, like the tail of a cat in a passion. Then again it will be retracted, and a casual observer might not imagine the Brachionus to be furnished with such a terminal implement."[1] It is not unusual to see one of these Rotifers sailing about in ease and comfort, with two or three eggs attached to the lower surface of the body near the foot.

Perhaps no Rotifer has been more widely or extensively known than that which is figured in older microscopical books as the "Wheel-animalcule." It is sometimes called the "Common Rotifer,"[2] and is

[1] Slack's "Pond Life," p. 125. [2] *Rotifer vulgaris.*

perhaps the commonest of all the species. The elongated body is terminated in its upper portion by a proboscis ciliated at the end—on which the two eyes are placed; on either side is the rounded lobe of the rotary organ, or "wheels," as they were called when their structure was almost unknown. The lower extremity terminates in a foot with two toes, and this foot is in reality telescopic, one tube within another, so that it may be shortened or elongated in the same way as a telescope is drawn out or pushed in. This little creature is found in all kinds of localities, in fresh water, even in gutters around the roofs of houses, besides ponds and ditches, and little puddles on heaths.

COMMON ROTIFER.

This Rotifer sometimes remains attached, whilst being examined under the microscope, by fixing its foot to some fragment of a water plant; at other times it is very restless, and keeps moving about in search of an eligible site. When it is possessed with this roving disposition, it will be seen that it travels as a caterpillar travels, by looping; just above the foot, its attachment is accomplished by means of a small round disc resembling a sucker; and the proboscis at the other end also attaches itself in the same manner, forming a kind of temporary sucker. Extending itself in full length, it waves about, and at last attaches its proboscis, then it draws up its nether extremity nearly

to the head. The little discoid sucker is seen attached to the glass, and the frontal extremity is thrust forward again to the extreme length of its attenuated body, and in this manner it soon makes rapid progress out of sight. In these movements it will also be observed how, in contracting itself, the Rotifer slides one joint into another, like shutting up a telescope. Of course whilst moving about in this restless manner, the "wheels" are not in operation.

It will be as well to caution the inexperienced observer of these organisms, that every Rotifer which may to him appear to be of this species may in reality be very different. It is by no means unusual to meet with another bearing a considerable family-likeness to it in the same situations, but which at a glance is seen to possess a most decidedly roseate hue. The rosy colour, however, is only a minor difference, for, as soon as the creature has become sufficiently quiet to undergo examination, the two red eye-spots—which, in the common Rotifer, are seated on the probescis—are in this Rotifer seated much lower down, upon what might be termed the breast, and wider apart from each other. This feature, combined with the rosy colour, will indicate the "Rosy Philodina."[1] The last time we saw this Rotifer, less than a week before penning these lines, it was on a minute fragment of a *Chætophora* (fresh-water algæ) that had been placed under the microscope for the purpose of determination, and, behold, no less than five individuals of this species of Rotifer made their appearance

[1] *Philodina roseolæ.*

at the same instant. What an immense number must have been present on that little tuft of green water weed! The bright rosy colour, sometimes much brighter than at others, adds considerably to the beauty of this animal. It moves through the water, when not too closely confined, by a swimming rather than a crawling movement; but when cramped for room, by being compressed, it has a gliding motion. We have always found it entangled amongst the tufts of some one of the filamentous Algæ.

Apropos of the Rotifers which linger amongst Confervæ, there is a pretty little fellow, clad in a carapace, or transparent shield, often found in such situations.[1] It is a small Rotifer, but a very active one, swimming about freely. The shield or transparent covering, is oval, pointed behind, and the foot is rather long, with two toes or divisions. The eyes are rather distant apart, but quite distinct. When quiet, amongst the *débris* of decaying vegetation, it may be seen perched on its foot, with its body bent forwards at right-angles, and a curious hook projecting from the front of its upper extremity. This hook is curved downwards, and has the shape of a miniature sickle. As the Rotifer poises itself on its foot, bending forwards, bowing, and bobbing up and down, it occasionally brings down the point of the hook to the Algæ amongst which it roams, and apparently scratches them, as a hen scratches in a farm-yard. Whether such a use is one of the functions of the hook, we cannot tell. It is perfectly clear and

[1] *Metopedia acuminata.*

colourless. But we have several times seen a rather larger, and it seems to be a different, species, with a slight rosy colour. This has the carapace at the upper end hollowed out, so that the two angles project like short spines, and there is no frontal hook. The toes are shorter than in the other species, but its habits and mode of life seem to be very similar. Some of the species have a ridge, like a keel, down the back, but in this one the back of the carapace is only gently convex.

It is much to be wished that some one would discover a method whereby Rotifers can be put to instant death, with all their organs fully extended, so that they may be mounted as permanent objects for the microscope. There are some minute creatures to whom a drop or two of sweet spirits of nitre supplies a "happy dispatch," for they immediately die with all their organs expanded, and in this state can be "mounted" and always examined. But, up to the present, no one has devised such a method applicable to the wheel-bearers. As they die they contract, and become beyond power of recognition, except those furnished with a shield, and the empty "casts" of these are as good as the dead animals. The most perfect "mounting" will never equal living animals for the purpose of study, but it must be remembered that living animals are not always to be found just when they are wanted. And, for scientific purposes, a good method of preserving these and similar animals is very requisite. It may be a very rare or unique individual which presents itself. A few hours, and it is dead and past recognition.

Nothing is left but hasty and imperfect sketches, and, as far as the interests of science are concerned, the creature might as well never have been seen. On the other hand, if some good mode of preservation were discovered, such an object might find a place in a national museum, to be referred to and consulted.

It very often happens that a happy thought, or a fortunate discovery, originates with those who are by no means adepts in science; and it is quite as probable that those who may read these pages, and discover that such a "want" is recognised, might contribute to its satisfaction, as those who have long felt the want, but never found the remedy. We commend it therefore to the consideration of those who have the will, and the leisure, and the aptitude, for investigation in microscopical manipulation.

WHIP-TAIL.

The "Whip-tail"[1] is, in its entire length, not more than one-seventieth of an inch, of which fully one-half is occupied by the long slender foot. It has only one eye-spot. This creature is to be found amongst Confervæ, swimming slowly, and in a stiff and awkward manner. When stationary the foot, is jerked backwards and forwards, and this, combined with its

[1] *Mastigocerca carinata.*

slender form, has procured for it the name of "Whip-tail." It will always be found productive of satisfactory results to examine closely amongst Confervæ for wheel-bearers. Even during February we have found no less than four different species of wheel-bearers amongst a few Confervæ from a pool on Hampstead Heath.

The Skeleton Wheel-bearer [1] is another of the rarer

SKELETON WHEEL-BEARER.

species, and is found amongst the Hornwort.[2] There are, indeed, two species, one with a shorter body and longer toes [3] than the one figured, and found also amongst duckweed. The prominent feature in the

[1] *Dinocharis pocillum.*
[2] *Dinocharis tetractis.*
[3] *Ceratophyllum.*

species figured, is, that it has two long spines at the base of the foot, which is terminated by three toes, of which one is shorter and rudimentary.

A curious Wheel-bearer,[1] with somewhat of a top-shape, but blunted at the lower extremity, is to be found amongst Confervæ. The chief interest, however, attaches to the presence of six long narrow blades, like fins, which project from each side, and are

POLYARTHRA.

moveable. These fins or wings give the little creature a most formidable appearance. No Wheel-bearer is so subject to parasites as this, and it is seldom seen without some of these adhering to its body, as shown in the figure.

It will afford great assistance to the young student

[1] *Polyarthra platyptera.*

of the Wheel-bearers to observe that some of them, as the Common Wheel-bearer, have flexible bodies, which retract or lengthen, and assume varied shapes; whilst others, such as the foregoing, are enclosed in a lorica or shield, like a tortoise, and, consequently, are not so polymorphous. The presence or absence of a shield will assist in determining their names.

The revival of Wheel-bearers after desiccation has long been known, and cited as one of the mysteries of low-life. Doyère, a French naturalist, says that they will revive, that is, pass from a motionless state to one of motion, after having been exposed to a cold of 20° below freezing point, or to a heat of 113° Fahr.; that they preserve the property of reviving in dry sand up to a temperature of 159° Fahr., but that they lose this property and remain immovable if warmed in moist sand to 131° Fahr. He also says that he has seen them slowly revive after being dried without sand. Ehrenberg has given a most complete history of all the observations instituted on the so-called revivification of Rotifers. He believes that, notwithstanding all the means of desiccation employed, life still remains in the apparently-dead animal. He contests the hypothesis of latent life; for death, he says, is not life in a torpid state, but the absence of life. Fontana mentions that he succeeded in restoring to animation, after two hours' immersion in a drop of water, a Wheel-animalcule which had lain in a dried and motionless condition for the space of two years and a half.[1]

[1] Humboldt's "Views of Nature," p. 240.

There are three kinds of minute creatures capable of enduring a great amount of dryness for a long period of time, resuming activity after the application of moisture; these are the Rotifers, or Wheel-bearers, the minute worm-like creatures called Nematoids, of which the wheat Vibrios are an example, and the Tardigrades or Water-bears, little creatures bearing a relationship to spiders and mites. There are others, such as some of the Entomostraca, which exhibit similar phenomena to a limited extent.

We might extend this enumeration considerably, but enough has been done to show the character of the different groups of these interesting little creatures, and we hope enough also to interest some of our readers in their habits and economy. We only regret that the few pages which we have been able to devote to over one hundred and twenty different species of British aquatic animals of this type do not enable us to enter into any details of their minute structure, and of their modes of increase and dissemination, and allow us to give but slight glimpses of their habits of life.

NOTE.—Since this work was first written Dr. Hudson's beautifully illustrated volume of "British Rotifers" has been published, which should be consulted by any who are desirous of pursuing this branch of our subject.

Improvements have also been devised in mounting Rotifers—by processes described by Mr. Rousselet at the meetings of the Quekett Microscopical Club, by means of which they are exhibited much better than hitherto was deemed possible.

## CHAPTER XI.

### LEECHES AND WORMS.

We must confess that there is some excuse for the great dislike which most people evince for such crawling creatures as leeches and worms. There are very few of the terrestrial or fluviatile species which are at all comely, none which we can truthfully declare to be beautiful. And yet, even leeches and worms are necessary in the economy of nature; they have their appointed places to fill and duties to perform, and for these their form and structure are so admirably adapted that we could conceive of no improvement. Undoubtedly the most attractive of Annelids are marine, but that would be no excuse for our omission of fresh-water species.

Leeches are, of course, worms of a certain character, that is, they belong to that large class known as Annelids, and popularly as Worms. Some persons suppose that all leeches belong to one of two species, the one named the Horseleech, and the other the Medicinal Leech. This, however, is a popular error, and not the only one associated with leeches. Certain leech-like animals which attach themselves to living fish do not come within our cognizance.

The Horseleech[1] is found in lakes and ponds, attaining a length of 4 inches, greenish-black on the upper, and yellowish-green on the lower surface; at least this is one of the suctorial leeches to which the name of horseleech is applied. There is also another leech,[2] which is not suctorial, as the rudimentary condition of the jaws disables it for piercing the skin of animals. It is doubtless this which most commonly goes by the name of horseleech. It also is about 4 inches in length, and similar in colour to the above. The true medicinal leech[3] is from 4 to 7 inches in length, greenish-olive, or very dark green above, with six broken yellow bands along the back. Of these three kinds of leeches, the first and last are suctorial, and the intermediate one is not. The medicinal leech was formerly common in this country, but it is now rare, especially in the south. Traditions of leech-gathering lingered till recently in the north, else wherefore those lines of Wordsworth:—

"He told, that to these waters he had come
To gather leeches, being old and poor;
Employment hazardous and wearisome!
And he had many hardships to endure:
Housing, with God's good help, by choice or chance;
And in this way he gained an honest maintenance."

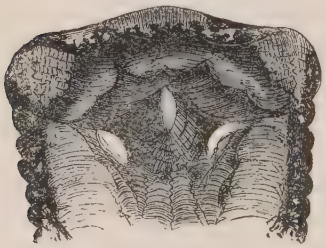
That they were becoming scarce, even at the time this poem was written, is evident from a succeeding verse:—

"He said, that, gathering leeches, far and wide
He travelled; stirring thus about his feet
The waters of the pools where they abide.

[1] *Hæmopsis sanguisuga.* [2] *Aulostoma gulo.* [3] *Hirudo medicinalis.*

'Once I could meet with them on every side;
But they have dwindled long by slow decay;
Yet still I persevere, and find them where I may.'"

The suctorial leech sucks the blood willingly of all the vertebrate animals; to accomplish which it attaches itself first by means of the sucker at its opposite extremity, and, a suitable spot being selected, it cuts through the skin. This is accomplished by means of its three teeth, embedded in a strong circle of muscular fibre. Each tooth is somewhat semicircular, with its free margin toothed, resembling a minute semicircular saw. If a leech be carefully watched, it will be seen that a sawing motion is given to each tooth by the strong muscles, and hence that the triradiate wound of a leech consists of three minute saw-cuts. The rest is known to many experimentally. There is, however, one fact about leeches not generally known, that they possess ten eyes, arranged in a curved line.



MOUTH OF LEECH (enlarged).

The Common Horseleech (*Aulostoma*) is a cruel and greedy worm, feeding on earthworms, grubs, snails, and other leeches, but, although carnivorous, it has only three small cartilaginous teeth, and cannot inflict a wound like the true leech, neither is it a suctorial worm. Stories are numerous in country

districts of the dangerous character of the horseleech, such as "nine horseleeches will suck a horse to death," &c., but, as observation and examination will prove that the horseleech could neither wound a horse nor suck it, all such stories must be fallacious.

Dalyell says of it —"This is an active, bold, and clever animal, frequently crawling out of the water, and apparently always ready to quit its vessel. None of the tribe surpass it in voracity. Few animal substances are rejected. All kinds of fish, dead or alive, seem acceptable. Penetrating the cavity of the larger fresh-water shells, the horseleech takes up a permanent dwelling there until emptying them of their contents, should it be able. Several of this species, and another, having been collected from the same place, one of the latter, half-swallowed by a horseleech scarcely double its size, was struggling for liberty. But its ferocious enemy, adhering firmly by the sucker, and undulating its body in the water, as if to aid deglutition, occupied three hours in finishing its task, when it appeared much distended by so copious a repast. Another attempted to devour a dead leech of a different kind, absorbing the smaller extremity here, as the former did with its living companion, but the latter proved too large for its gullet. Considering the strength of the prey, indeed, and the adhesion, it appears a hardy effort of leeches to devour each other, unless under great disparity of size."

The Eight-eyed Leech[1] is also one of the non-suctorial leeches found in stagnant or slow-running water,

[1] *Nephelis octoculata.*

but it is very small, not exceeding an inch and a half in length, and of a reddish-brown colour, with variable markings. It does not appear to be at all common. It is a very active leech, swimming in the water by an undulatory or serpentine motion of the body. "The structure of the mouth unfits it for eating solid food, or biting through the skin."

The residue of our leeches belong to a different tribe; they are small and usually very transparent; there are certainly six, and perhaps nearly double that number, of British species, inhabiting ponds, dwelling amongst the aquatic plants, but incapable of swimming, and not voluntarily leaving the water. Most of them have but six eyes, some of them have apparently but two, whilst one has eight. The Chequered Leech[1] is perhaps the best known, and that appears to be a northern species. As it is with the rest of the Annelids, so is it with the leeches:—so few persons have taken any interest in them that it is not truly known what species are to be found in the British Isles, or the extent of their distribution; and, for our knowledge of their structure, habits, and economy, we are mainly indebted to Continental writers.

There is another small group of aquatic worms called Naides, which are very vivacious in their habits, creeping about amongst aquatic plants, and can even swim. They are supposed to live upon the smaller members of the family of water-fleas, but there is not much of special interest attached to them, calling for more than a brief passing notice.

[1] *Glossiphonia tessellata.*

There are to be found in our ponds and ditches a great number of little broad, flattened worms, with some resemblance to "flukes," which are covered with cilia, and lead such a retired life that very little is known about them. The name of Planarian Worms is sometimes heard, but very few, even of those who are always in search of objects for the microscope, have the slightest idea of their character, structure, or habits. These obscure animals are small, the largest of the pond species scarcely exceeding half-an-inch; they are also unattractive, and, worst of all, there is no book in the English language to assist in their study. They are so soft and gelatinous in their nature, that when dead the majority of them decompose and become a watery mass, in the course of one or two minutes. The commonest little black fresh-water Planarian[1] belongs to a genus characterized by the possession of many eyes, but species of true *Planaria* will be found abundantly in company with it. Dugès describes the wonderful power of reparation of injuries which they possess. "By slitting them with scissors individuals may be produced with two heads or two tails, and otherwise modified." In one species certain organs have been described as probable spinnarets, like those of a spider, but there is some uncertainty about them. Dalyell, in one of his works, notices two or three species of Planarians as apparently spinning, and hanging by the threads. When even amongst professed naturalists so very little is known about

[1] *Polycelis nigra.*

them, we cannot be expected to do more than thus indicate their existence.[1]

The mud of ponds and ditches, as well as that of rivers, is often to be seen literally covered with little protruding red worms, from 1 inch to 1½ inch in length, with half the body immersed in the mud and the other half exposed. They possess such facilities for the reproduction of the species that they increase with great rapidity, and may often be seen in such numbers as to cause patches of red on the surface of the mud in which they burrow. When disturbed they withdraw their bodies into the mud, and with them the red patches instantly disappear. This little creature is the Summerworm, or Red River-worm,[2] and belongs to the same family as the earthworm, but has much more interest, because of its delicate uncoloured skin, through which, as through glass, the whole of its internal economy may be seen and studied. The red appearance of these creatures is due to the blood-vessels seen through the transparent skin; and here we have an open book, which the inquisitive may read, and learn all the mysteries in the life of a little worm, with its two hearts, its large liver, its blood-vessels, its nervous centres, and indeed its whole nervous and circulatory system, even to the discovery of its parasite, a little Infusorian which dwells in its interior, and seems to enjoy itself within a world entirely its own. The annuli or rings can be seen and counted under a

[1] Ray Lankester, on Planarian Worms, in "Popular Science Review," vol. vi., p. 388.

[2] *Tubifex rivulorum*. See also "Popular Science Review," vol. ii., p. 10.

lens, and by the same means the two lateral rows of bristles may be distinguished. Notwithstanding the general dislike which most persons feel towards all such creeping animals as snakes and worms, it is well to suppress such a feeling for a while in favour of this harmless little "red-worm," and learn some of the many lessons it can so readily teach.

There are to be found, in localities and in situations which are variable, certain small, slender, worm-like creatures to which the name of Nematoids has been applied. Some of these come within our jurisdiction, and therefore demand some notice. Three Nematoids may be named, with which most persons are familiar, and these will serve as excellent types of the kind of creatures concerning which we are writing. These three are called, the Vinegar-Eel, known to microscopists as developed under certain conditions in vinegar; the Paste-Eel, which any one may soon rear for themselves from stale paste; and those minute eel-like bodies called Vibrios, found in wheat suffering from the disease called "Pepper-corn" or "Ear-cockle." These are all examples of Nematoids. They are minute, eel-like, or worm-like creatures, the structure and anatomy of which may be studied in special memoirs devoted to the subject. In size they vary from one-seventieth of an inch to three-quarters of an inch in length; and the sort of places in which they are found are thus summarised by Dr. Bastian:—"Beginning with the land and fresh-water species, I have found them in all the specimens of soil examined, in moss, in various species of lichens, about the roots of fungi, also in the roots of grasses, and between the

sheaths of their leaves, amongst the mud of ponds and rivers, on the fresh-water Algæ, amidst decaying liverworts and mosses, and on submerged aquatic plants."[1]

They differ very much in the amount of activity which they exhibit, some being slow and tardy, whilst others are quite the reverse. The mode of locomotion is the same in all; it consists chiefly in those eel-like undulations which obtained for the well-known species the name of "eels." At times they climb and twine amongst the Algæ and other water plants, which they frequent, in a serpentine manner, or anchor themselves firmly by means of a sucker at the tail, with which all the species are provided; on such occasions they sway themselves backwards and forwards for a while, and then dart off with great celerity.

NEMATOID.

The free Nematoids—for there are also parasitic Nematoids, with which we have nothing to do—are chiefly vegetable feeders, taking a small quantity of food at a time. Their power of repairing injuries seems but slight, for when accidentally divided they will linger for about a week, during which time both parts will continue to move about, and then die. On the other hand the tenacity of life in some of the species is most

[1] Bastian, "Anatomy and Physiology of the Nematoids," "Philosophical Transactions," 1866.

remarkable, of which the Vibrios of wheat is also a familiar example. Thus Baker ascertained that some of the animals contained in diseased wheat given to him by Needham in 1744 still possessed the power of resuming all their vital manifestations in 1771, after immersion for a time in water. The results of one experiment conducted in France will illustrate the power possessed by Rotifers, Tardigrades, and Nematoids of reviving after desiccation, sufficient, it would have been thought, to dry all vitality out of them. "Portions of moss which had remained sixty-seven days in a cabinet, were submitted for two days to the influence of dry air, and during fifty-one days to the action of a vacuum. The mosses then became so completely dried that, after four days of exposure to the double influence of a vacuum and sulphuric acid, they underwent not the slightest diminution in weight, and yet, after twenty-four hours of simple moistening with water, the Rotifers, the Sloths, and the Nematoids had completely regained their vitality."

There is one species which may be alluded to, found on the mud of ponds, which has the habit of coiling itself into a circle when touched.[1] Others occur also on the mud of freshwater pools, and several species inhabit the water milfoil, which harbours so many aquatic animals. The general appearance of all is very similar, and it is doubtful whether any but the scientific will take much interest in their distinctions.

Only a worm! Why trouble more about the nasty

[1] *Trilobus pellucidus.*

crawling things? Only a worm! Such an ejaculation, and with an emphasis too, has been heard once and again. Would that we could whisper in the ear of him who next is prepared to utter it a word of caution. Was it not He who made the world, He who created Man, that also called into being, for some good purpose of His own, the poor, despised worm?

## CHAPTER XII.

### SPIDERS, MITES, AND WATER-BEARS.

It is very usual for ordinary people, who lay no claim to be considered scientific, to speak of spiders and mites as "insects," and no great crime is committed by such an act, although learned professors might be horrified. The fact is, that although formerly included with insects, the advance of science has pushed them out of the class of insects and sent them into the neighbourhood of the crustaceans. So that it is no longer accurate to speak or write of spiders and mites as insects, under pain of being regarded as an "ignoramus."

Spiders and mites are very numerous, the latter especially so, and yet very few of them are aquatic. In this country it is usual to speak of *the* water-spider, which assumes that we have but one species with such habits; yet, Mr. Blackwell, who is one of our best authorities on such subjects, says that "several of the semi-aquatic species belonging to two genera,[1] run fearlessly on the surface of the water, and even descend spontaneously beneath it, the time during which they can respire when immersed depending upon the supply of air confined by the

[1] *Lycosa* and *Dolomedes.*

circumambient liquid amongst the hairs with which they are clothed."[1]

The Argonaut, or Argyroneta,[2] was at one time common enough in ditches, and, for a period enjoyed a dangerous reputation, since it is large enough to permit its movements being watched with facility. Its interesting habits are well known, and have led to their being often kept as pets. Indeed, a few years ago it became so much a fashion that, like sea-anemones during the rage for aquaria, they have become scarce, even in localities such as the ditches about Oxford or Cambridge, which are most adapted for them, and where they were formerly plentiful, they having been caught and sent up to London in quantities for sale by dealers in objects of natural history.

WATER-SPIDER.

They can live indifferently, either on dry land or under water, but practically they spend the greater portion of their time in the latter. Their eggs are moored in silken cocoons to the stems of aquatic plants, under a dome-shaped cell, which is filled with air like a diving-bell, by the spider carrying down successive globules of air between its legs, which it liberates under the dome until it is filled, and the

[1] "British Spiders," p. 16.

[2] *Argyroneta aquatica.*

young are hatched there. The spider on its way through the water never gets wet. It is clothed with hair, which, combined with its respiratory organs, enables it to surround itself with a halo or enveloping bubble of air in which it moves about protected from wet, and well supplied with air to breathe. It can be drowned for want of air, however, as well as any other animal—Mr. Blackwell mentions such a case. "One of these creatures which had been got in the fens of Cambridgeshire was given to a friend. On being placed in a large goblet more than half-filled with water, it speedily formed its dome-shaped cell beneath the surface, attaching it to the side of the glass by means of numerous silken lines, and, being well supplied with insects, it lived in this state of captivity till the commencement of winter, when, on the temperature of the room in which it was kept becoming much reduced it entered the cell, and remained there in a state of torpidity with its head downwards. A gentleman on a visit at the house, whose curiosity to examine the spider minutely in its hybernaculum was greater than his prudence, inclined the glass so much that the air escaped from the cell, the water flowed in, and before information of the circumstance was given the dormant spider had perished. The spider feeds upon any insects it can catch, whether land or water species; and whether she gets them on shore or not she generally carries them into her cell to suck their juices there."[1]

The Piratic Spider[2] is less than 4-10ths of an inch

[1] Murray's "Economic Entomology," p. 73. [2] *Lycosa piratica.*

in length, of a brown colour, with white spots, and frequents the margins of pools. It runs rapidly on the surface of water, even when carrying its cocoon, and "frequently takes refuge from danger beneath the surface of that liquid, concealing itself among the leaves of aquatic plants." It can carry down with it sufficient air to remain immersed for a considerable time.

Another, and one of the largest of British spiders,[1] with legs upwards of an inch long, is of frequent occurrence in the fens of Cambridgeshire, and, like the foregoing, descends spontaneously beneath the surface of the water. The body and abdomen are of a reddish-brown colour, with a broad paler longitudinal band on each side. It is quite possible that these are not the only spiders we have which will take to the water, as the number of observers capable of distinguishing the species are remarkably few.

Familiar objects to the pond-collector are the little bright vermilion mites which swim about vigorously amongst the water-plants. Little bright red dots, and to the naked eye they are scarcely more, float about in the clear water, but never in numbers, only two or three being seen at a time. Some there are, it is true, which never swim at all, but are content to crawl over the surface of the submerged vegetation. Under a lens the little red dots are seen to resemble a spider in shape, indeed, they are sometimes called "little red water-spiders," but the name of water-spider belongs of right to the larger animals. These, which to the

[1] *Dolomedes fimbriatus.*

naked eye seemed only red, are by enlargement found to be marked with black dots or bands; and all are not black, for some are yellow, and some also green.

It is well known amongst naturalists that the water-mites have in their earlier stages fewer legs than the mature individuals. In some of the genera they are said to have but three at first; it is common to see them with only six; when mature they should have eight. The young ones are hatched from eggs which are deposited on the stems of water plants. It is a curious fact that after being hatched the young in some instances, before they are capable of swimming, attach themselves to the bodies of water insects, such as the bugs and beetles, and are carried about by them until they are able to move about freely on their own account.

WATER-MITE (*Diplodontus*).

Although some of these little animals were observed and figured in this country some years ago, no one has made their study a special subject, and consequently we are far behind Continental naturalists in our knowledge, not only of the water-mites, but of all the Acari.[1] Of course the subject is beset with difficulties, and so is every subject, for there is no royal road to knowledge; but we have observed young men, who commenced enthusiastically with

[1] Figures and descriptions of the different genera of water-mites are given in Murray's "Economic Entomology" (*Aptera*).

water-mites twenty years ago, subside gradually, until at length the objects in question were never mentioned.

There is not only considerable difference between the appearance of the young mites and the mature ones, but also between the male and female of the mature animal; this increases the difficulty of recognition, so that we cannot be said to know any one species until acquainted with its entire life-history.

POND-MITE (*Eylais*).

The number of mites which inhabit a variety of places, terrestrial and aquatic, in this country must be very great, since some characteristic form or other is sure to be met with, even under the most unexpected conditions. It might almost be doubted if a locality could be found where a mite would not make itself at home, parasitic or non-parasitic, in fresh water or salt, amongst food or poison, on animal substances or vegetable, single or in colonies, smooth or hairy, with long legs or short ones, bodies round or long, nearly square or triangular, white, black, brown, red, yellow, or green. The difficulty would rather be to name conditions and places in which they could not thrive.

The Water-bears are curious, and in some respects remarkable little creatures, second cousins to mites and spiders, but with very little family likeness. Some are found crawling over aquatic plants, and it is with these that we are chiefly concerned; others nestle amongst the tufts of moss on the roofs of

houses where they pass through alternate periods of great moisture and great dryness; others occur on tufts of moss in damp situations. They are little creatures with oblong bodies, furnished with eight short feet armed with claws. Their usually sluggish movements have originated the name of Tardigrades, or slow-walkers, but they are more commonly known as little Water-bears. We know but little of their history, and this has been summarised by Mr. Slack.[1] The figure was like that of a new-born puppy or bear-cub; each of the eight legs was provided with four serviceable claws; there was no tail; and the blunt head was susceptible of considerable alteration of shape. He was grubbing about among some bits of decayed vegetation, and, from the mass of green matter in his stomach, it was evident that he was not one of "the starving poor." The movements of the Water-bears, although slow, evince a decided purpose, and ability to make all parts work together for a common object; and as might be expected from this fact, and also from the repetition of distinct, although not articulated limbs, they are provided with a nervous apparatus of considerable development, in the shape of a chain of ganglia and a brain, with connecting filaments. Like the spiders, they cast their skins.

WATER-BEAR.

[1] "Pond Life," p. 173.

The Water-bears possess, in common with the Rotifers, the power of supporting protracted desiccation, and of reviving on the application of moisture. Pritchard says that they can be revived after being put into hot water at 113° to 118° Fahr., but are destroyed by immersion in boiling water. "They may be gradually heated to 216°, 250°, and even 261°. It is also by their capability of resuscitation after being dried that they are able to sustain their vitality in such localities as the roofs of houses, where at one time they are subjected to great heat and excessive drought, and at another are immersed in water." In a memoir, written upon this very subject, Doyère, a French naturalist, thus summarises his experiments. "Desiccation conducted in an ordinary temperature might be open to many objections, which are not perhaps wholly obviated by the employment of a vacuum, but when we observe that the Tardigrades irrevocably perish in a temperature of 131° Fahr., if their tissues are permeated with water, whereas they can, when dried, support a temperature that may be estimated at 248° Fahr., we are disposed to admit that the sole condition required for animal revivification is the perfect integrity of organic structure and continuity;" and Humboldt, after comparing these phenomena with the winter sleep of reptiles, adds, "the apparent revivification of the Rotifers and of the silicious shelled Infusoria, is only the renewal of long-enfeebled vital functions—a condition of vitality never entirely extinguished, but merely revived by excitation."

## CHAPTER XIII.

### WATER-FLEAS.

A LITTLE group of minute aquatic Crustaceans has obtained the name of "Water-fleas;" not that they really are fleas, but because of their brisk, jerking motions, almost like leaping in the water. Being Crustaceans, they have a relationship to shrimps and lobsters, agreeing with them also in being aquatic, but differing considerably in size, the largest British species not being more than one-fifth of an inch in length. Their scientific name is *Daphnia*, first called Daphne, probably because in classic story Daphne was a daughter of the river Peneus, albeit the water-fleas delight rather in stagnant than running water, and are rather the daughters of the horsepond than the river. They are only to be found in fresh water; some preferring ditches in which there is much duckweed floating on the surface, others delighting in ponds where cattle come to drink. In such places they are to be found in myriads, nearly all the year round, and as they sometimes assume a red colour, they have been said to have tinged the water with the hue of blood. Swammerdam observed this fact two centuries ago, and he says that he has seen them in such numbers at Vincennes as actually to give the water of a horsepond the colour of blood. "I have," writes

Dr. Baird, "frequently seen large patches of water in different ponds assume a ruddy hue, like the red rust of iron, or as if blood had been mixed with it, and ascertained the cause to be an immense number of *Daphnia pulex*. The myriads necessary to produce this effect is really astonishing, and it is extremely interesting to watch their motions. On a sunshiny day, in a large pond, a streak of red, a foot broad and ten or twelve yards in length, will suddenly appear in a particular spot, and this belt may be seen rapidly changing its position, and in a very short time wheel completely round the pond. Should the mass come near enough the edge to allow the shadow of the observer to fall upon them, or should a dark cloud suddenly obscure the sun, the whole body immediately disappear, rising to the surface again when they have reached beyond the shadow, or as soon as the cloud has passed over."[1]

The body of the Water-flea is composed of two portions: the smaller forms the head, the larger consists of the thorax and abdomen, contained within a delicate shell. The valves of this shell are marked about their centre with a reticulation of faint lines. They are united along the hinder margins, and open in front, the lower extremity in some species being prolonged into a kind of spur of variable length.

The head is lengthened out in front to a kind of beak, beneath which are the superior antennæ (differing greatly in the two sexes of the same species). In the female these antennæ are very small. On each side,

[1] Baird's "British Entomostraca," p. 78.

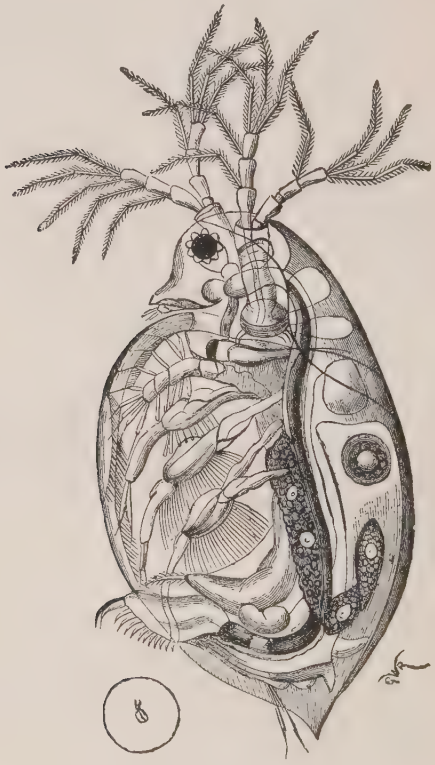
at the base of the head, the larger antennæ are attached. These consist of a single joint, dividing upwards into two branches, the posterior of which has four joints, the other three. Both branches are furnished with long filaments, which in some species are feathered throughout their length.

The eye of the Water-flea is spherical, and composed of about twenty lenses. The mouth is a somewhat complicated organ, and consists of a lip, two mandibles, and a pair of jaws seated near the junction of the head with the body. The stomach is plainly distinguishable as a long vessel curved upwards at its lower extremity. The body consists of eight segments, the upper of which only is attached to the shell. An ovoid vesicle at the back of the first segment, subject to rapid contractions during the life of the animal, is the heart. All the species of *Daphnia* have five pairs of legs; these are variable from each other, and may be observed in motion through the transparent shell. The eggs having attained a certain period of development in the ovaries of the female are ejected, and from that time until fully mature are carried in the space between the back of the body and the shell.

The Common Water-flea[1] is found in almost every pond and ditch during nine months of the year. The male is much smaller than the female, and is comparatively rare. It has been asserted that their food is entirely vegetable, but Dr. Baird was of opinion, after various experiments, that on the contrary they

[1] *Daphnia pulex.*

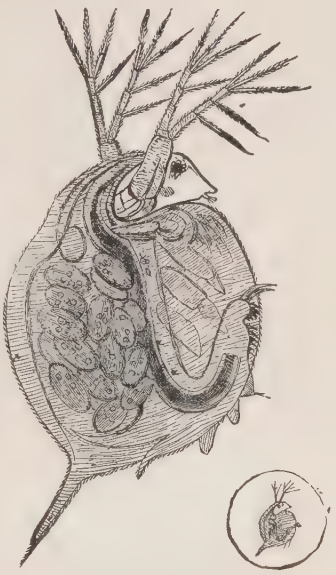
subsisted chiefly on minute infusoria, and that they are therefore wholly carnivorous.



COMMON WATER-FLEA.

A still larger species is that which may be termed

the Great Water-flea,[1] which has been found on Bexley Heath and other places around London. It is as much as one-fifth of an inch in length, and two lines broad. The terminal spine at the lower edge of the carapace is very long, being proportionately twice as long as in the Common Water-flea. Their motion through the water, says Dr. Baird, is peculiar, being a tumbling, heavy sort of movement, and when seen in their native ponds they seem to keep near the bottom. When at the bottom of the vessel in which he kept them, he frequently saw them turn head over heels, throwing a regular summersault, ten or a dozen times in succession.

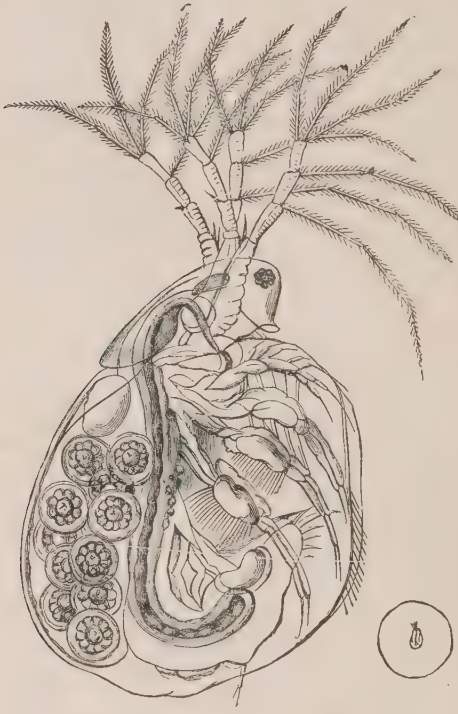


GREAT WATER-FLEA.

Another species found in the neighbourhood of London, commonly and plentifully throughout summer and autumn, is the Spineless Water-flea,[2] which

[1] *Daphnia Schæfferi.* [2] *Daphnia vetula.*

is sufficiently to be distinguished for our purposes by the absence of the spine at the lower extremity of the carapace. The smaller head and greater breadth of



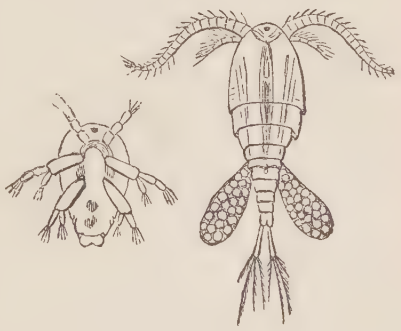
SPINELESS WATER-FLEA.

the lower portion give an almost reversed pear-shape to this species.

There are several others which are also found more or less commonly in Britain, but their differences and distinctions are of more interest to the professed naturalist than they would be to us; we will therefore leave the remaining four species unnamed, and pass on to other creatures similar to the water-fleas, and which are systematically associated with them.

In olden times there was said to be a race of men of gigantic stature, called Cyclops, and they had but one eye in the middle of their foreheads. These were the Cyclops of romance, but the Cyclops of reality are by no means a race of giants, but minute little Crustaceans, scarcely larger than the Water-flea, and living in the same localities. They have also been called Monocules, because, like the Cyclops of old, they have but one eye in the centre of what may be called the forehead.

The form of the Cyclops[1] is very different from that of the Water-fleas, being of an elongated pear-shape or club-shape, attenuated downwards, and ending in two elongated lobes



CYCLOPS.

[1] *Cyclops signatus* and *Cyclops tenuicornis.*

embellished with transparent setæ of variable length. From the upper extremity proceed two pairs of antennæ, one pair larger than the other, and from these the species formerly obtained its name of *Quadricornis* (four-horned). In the males the form of the antennæ is different, and serves to distinguish the sexes. In its progress through the water the Cyclops moves with a rapid jerking motion, which may be seen by holding a bottle containing them up to the light. It will then be observed that the principal propelling organs are its oar-like feet, of which it has five pairs. Each foot, which may be said to be double, consists of a common stem, from whence arise two-jointed branches, liberally furnished with setæ, or bristle-like appendages. The fifth pair are rudimentary, and differ with the sexes.

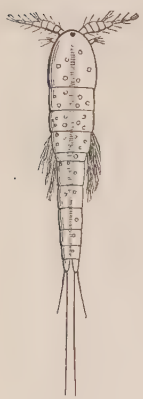
The females greatly preponderate, and are easily recognised by their external ovaries, which hang suspended on each side of their bodies like miniature clusters of grapes. Leeuwenhoek says that in specimens which he saw of this species he counted the eggs, and found them arranged three or four in breadth, and nine or ten in length; Dr. Baird says that females are often seen carrying 30 or 40 eggs on each side. Jurine, who watched carefully the hatching and increase of this species, says that "he has seen one female isolated lay ten times successively, but in order to speak within bounds he supposes her to lay eight times within three months, and each time only 40 eggs. At the end of one year this female would have been the progenitor of 4,442,189,120

young, that is near four-and-a-half thousands of millions. The first mother lays forty eggs, which at the end of three months, at eight layings during that time, would give 320 young. Out of this number he calculates 80 as males (there being in every laying a great proportion of females) the remaining 240 are females."[1]

It is easy to write, but not easy to comprehend such an immense number. Let us suppose a man to count this progeny, one by one, at the rate of sixty per minute for twelve hours per day, for six days a week—a rate it would be impossible to sustain — it would occupy him for three hundred and twenty-nine years and a-half and upwards, to count all the progeny of one female Cyclops during twelve months. In reality such a progeny never survives, because they are continually the victims of predacious animals, but this is an estimate of the enormous possibilities of increase, were all conflicting and antagonistic circumstances removed. Millions fall victims to trout and other fish, and the delicate flavour of the former is said to be in a great measure owing to a plentiful supply of this living food. The Hydra, and the larvæ of aquatic and terrestrial insects, all play their part in the work of destruction, and thus lend a helping hand in keeping down that teeming abundance of life which would otherwise choke up our ponds, ditches, and streams with animal life, until existence under such circumstances would become an impossibility.

[1] Dr. Baird's "British Entomostraca," p. 190.

The Vaulter or Little Cyclops[1] differs from the true Cyclops in several particulars, viz., the female only carries about one pouch of eggs, the body more gradually attenuates downwards, the size is smaller, &c. It also is found in ponds and ditches all the year round. It can hardly be confounded with a small species of genuine *Cyclops* which is also very common in ponds, but from which the females may be distinguished at a glance by the number of egg-pouches.



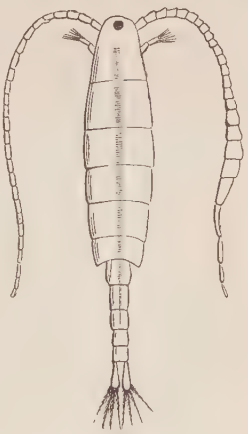
VAULTER.

Another member of this family is one which may be known as *Castor*,[2] which, in like manner, carries about only one pouch of eggs. It has been observed that the eggs of Castor are carried about by the parent until the young are hatched, whereas in the Cyclops they are carried only till they approach maturity, and are deposited before the young ones make their escape. All the species of Entomostraca, as these little Crustaceans are called, are produced in immense numbers, and constitute the natural food of many aquatic animals in the mature or larval condition. If it were not for some such check on over-population all our standing waters would teem with them, on account of their rapid increase.

There still remains a group of minute little Crus-

[1] *Canthocamptus minutus.* [2] *Diaptomus castor.*

taceans which must not be entirely forgotten. These are called scientifically the *Cypridæ*, and the body is enclosed in a covering of two valves, like a bivalve-shell, which in general appearance closely resembles that of a microscopical mussel, so much so that, as Müller remarks, a person at first sight would suppose that it was a parasite inhabiting the shell of some small mollusc. The animal has two pairs of antennæ, and two pairs of teeth, with one eye. They inhabit every pond and ditch where the water is stagnant, but not putrid. The genus *Cypris* comprises at least fifteen different species, and the individuals swim freely in the water, moving in all directions. This arises from the bundle of long feathery setæ which spring from the posterior antennæ, by means of which they can suspend themselves in the water, or transport themselves through it with great facility. The other genus, called *Candona*, with not more than one-third the above number of species, is deficient in this apparatus, and hence the little animals have to rest content with crawling along the mud at the bottom of the pools in which they are found, or creeping over the aquatic plants which grow there, without being able to suspend them-



CASTOR.

selves for the shortest time. These little creatures are not so prolific as the Cyclops; but in some of the larger species as many as twenty-four eggs have been counted. The males have never been discovered. The eggs are perfectly round, and are deposited by the animal upon some solid body, such as part of a plant, in a mass, which at times,

CYPRIS.

Straus says, consists of some hundreds from various individuals, the mother fixing them to the surface of the body on which they are deposited by means of a glutinous substance, and then leaving them. The eggs are hatched in about four days and a-half. Before maturity they pass through several moultings, the frequency of which depends on the season of the year.

The food of these little creatures consists of dead animal matter, confervæ, &c. Straus says he never saw them attack living animals when they were well and strong, but he has frequently seen them attack

worms when wounded and weak. Though dead animal matter was their choice, they will not, he adds, eat it when putrid. "They no doubt," writes Baird, "also prey on each other, as I have often observed individuals of one species devouring eagerly the dead carcases of species different from themselves When the ponds and ditches in which they live dry up in summer, they bury themselves in the mud, and thus preserve their lives as long as the mud retains any moisture, becoming as active as ever when the rain falls, and again overflows their habitations. After long-continued drought, however, when the mud becomes very dry and hard, they perish ; but the eggs do not perish along with the parents, for they can be hatched in four or five days after being placed in water."

Instead of being fixed to one place, and condemned to live amidst eternal darkness, like the molluscous animals to which they bear such resemblance in external covering, "they," to use the words of Müller, "by opening their valves, enjoy light, and move at their will, sometimes burying themselves in the mud, sometimes darting through the water, the humid air of their sphere. If they meet any unforeseen object, they conceal themselves all at once in their shells, and shut the valves, so that force and address seek in vain to open them."

But what are the uses of these little Crustaceans in the economy of nature? This is a question which Dr. Baird set himself to answer in the Introduction to his volume. He says, that "the greater number of these little creatures are furnished with branchiæ,

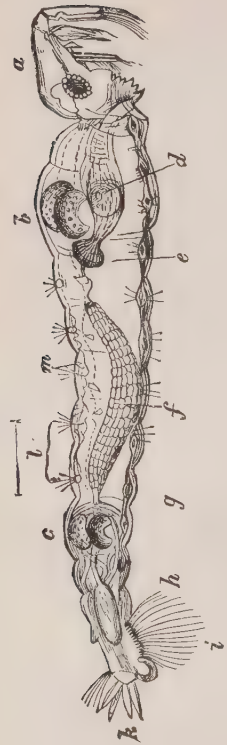
either to their feet or maxillæ, and when noticed in their native habitats may be seen to have them in constant motion, their action being seldom interrupted. One chief use, therefore, of them in the economy of nature may be, as Müller says, to ventilate the water day and night; and as they chiefly reside in standing pools, they may thus be of great use in preventing them from becoming putrid." And again —"I have no doubt that most of the Entomostraca are essentially carnivorous, and I have frequently seen specimens of Cypris in their turn, as soon as dead, attacked immediately by quantities of Cyclops, who, in a few minutes, had fastened themselves upon the dead animal, and were so intent upon their prey that they were scarcely frightened away from it by being touched with a brush. In a short time, the Cypris might be seen lying at the bottom of the vessel, the valves of the shell separated, and emptied of their contents. When, indeed, we consider the amazing quantity of animals which swarm in our ponds and ditches, and the deterioration of the surrounding atmosphere which might ensue from the putrefaction of their dead bodies, we see a decided fitness in these Entomostraca being carnivorous, thus helping to prevent the noxious effects of putrid air, which might otherwise ensue; whilst they, in their turn, become a prey to other animals, which no doubt serve their purposes also in the economy of nature."

## CHAPTER XIV.

### AQUATIC LARVÆ.

THE higher forms of animal life have been included in another volume of this series,[1] where will be found a record of the "birds, beasts, and fishes," of aquatic habits, and hence there is fortunately no necessity to repeat them here. Such of the reptiles as are aquatic have also been illustrated in the same work; and, in like manner, all mature insects which are generated in marshes, hover over swamps, or spend their brief term of existence in the neighbourhood of water, belong to that volume. In accordance with our original definition, we have to concern ourselves only with such insects as live immersed in the waters, and as these chiefly pass only their larval stages in that condition, the heading of this chapter indicates the narrow limits within which we deem it necessary to confine our observations on the true insects of ponds and ditches. Insects, according to the scientific limitation of the term, is much less diffuse than the popular designation of "insect," which is often carelessly applied to any minute animal, whether spider, mite, cyclops, infusorian, wheelbearer, and even the smaller worms. We are forced to make but a very

[1] 'Lakes and Rivers.'




PHANTOM LARVA.

*a*, head, *b*, thoracic air-cells, *c*, abdominal air-cells, *d*, œsophagus, *e*, gizzard, *f*, stomach, *g*, commencement of intestine, *i*, fan-like fin, *k*, four branchial leaflets, *m*, dorsal vessel.

brief passing allusion to some of the most common and distinctive larvæ which our localities furnish.

There is no insect-larvæ more common in still waters, or better known than that called the Phantom Larva.[1] No less than three elaborate dissertations on its anatomy and physiology, by most competent men, were published almost simultaneously.[2] It is familiar to every pond collector, and has been for generations, and yet its life-history is not yet fully traced through all its changes. It is the larva of a two-winged insect, and so crystalline in its nature that it moves like a phantom through the water, whence its name. As Dr. Carrington justly observes, "they are so translucent that, unless you know what to look for it is difficult to make them out in the water. Their specific gravity also coincides with that of water, so that they are enabled to float

[1] *Corethra plumicornis.*

[2] Ray Lankester in "Popular Science Review," vol. iv., p.

near the surface, or bottom of the vessel, without apparent effort. They differ from all larvæ with which I am acquainted by this habit of remaining suspended in mid-water, seldom seeking the surface for purposes of respiration, as in the case of other Diptera. I must not, however, allow you to form the impression that their habits are sluggish and inert. Far from this, their quietude is that of the eagle, for, like that bird, they are watchful and ready to pounce in a moment on any object moving beneath them. Their spectral appearance, and the mysterious manner in which they vanish, and reappear in unexpected places, will explain their name. One habit seemed at first especially 'uncanny,' the sudden way in which they make a half-turn, like the needle of a magnet, so that if we are examining the head, we find the tail substituted in its place, and before we have time to make out the details—presto! the head as suddenly appears! Our phantoms are, I fear, not so innocent as phantoms should be. We may rather compare them with vampires which suck the life-blood of unwary victims—a glance at the cruel armature of the mouth will satisfy you of this fact. Our larvæ are very pugnacious; they are continually butting at one another, after the manner of rams; and when one commences an assault, the spectators are certain to join in it."

In order that our figure of this larva may be comprehended in its details it will be essential to give an outline of its structure. The body is about half-an-inch long, gradually tapering to the tail, there are no

605; Prof. Rymer Jones in "Quart. Micro. Journ." vol. vii. p. 99; Dr. B. Carrington, "Science-Gossip," April, 1868.

feet or other appendages, except at the posterior extremity. The third segment of the body is the broadest and most prominent, and contains two air-sacs (*b*); and again it is slightly humped at the ninth segment, which also contains two air-sacs (*c*). The skin is delicate, smooth, and punctate. On the sides of the segments are scattered compound hairs. Terminating the body are four small branchial leaflets (*k*), with four bristles above them and below; on each side of the rectal opening, two hooked claws. Along the mid-line of the under side of the tail is a fan-shaped cluster of bristles (*h*, *i*), which serves at the same time as a helm and a powerful scull. The head (*a*) is compressed laterally, so that it appears wedge-shaped when seen from above. The frontal portion is prolonged into a kind of snout. The eye is compound, formed of a number of button-shaped lenses, those on the outer circle, resembling a chaplet of beads. The black dots on the external surface of the body are pigment cells, which are easily detached after death.

Circulation in insects is imperfect. Its motive organ is the dorsal vessel (*m*), in fact, a compound heart, divided into segments by means of valves, which allow the blood to flow forward towards the head, but not to return. In this larva it is a well-marked contractile organ, with delicate walls, broadest near the tail. The œsophagus (*d*) is narrow when empty, but capable of considerable distention. Its walls are thin, and consist of three layers. At the lower end the œsophagus contracts and communicates with a curious compressed gizzard (*e*) formed of two

valves, not unlike the valves of the diatom called *Navicula*, and in like manner marked transversely with raised parallel lines. A very narrow canal connects this organ with the proper digestive cavity or stomach (*f*), which is readily distinguished by its brownish colour, derived from the large secreting cells of its inner surface. Its chief direction is serpentine, pointing downwards, and opposite the eighth segment it contracts into a narrow small intestine (*g*), and at the same time is joined by four threadlike biliary ducts; hence it passes to an oblong colon and terminates in a short rectum (above *h*).

Insects are air-breathing animals, and the air is carried to their tissues directly by vessels called tracheæ, kept open by means of an elastic spiral fibre like the gas tubes so much in use. There are usually two main longitudinal trunks, from which branches proceed to the segments, and ultimately to every nerve and muscular fibril in the body. The only traces of longitudinal tracheæ yet found in this larva are the four air-sacs (*b*, *c*) in the third and ninth segments. These are attached in pairs. Seen from above they are oval, with the surface irregularly reticulated with black dots. No trace of air-vessels connecting these sacs was found. It is the opinion of some observers that the two pairs of air-sacs (*b*, *c*) only serve the purpose of floats to assist the larva in its progress through water, but with this conclusion Dr. Carrington does not agree.[1]

There are also the larvæ of other two-winged flies

[1] "Science Gossip," 1868, p. 80.

which swarm in stagnant waters. Notably amongst these are gnats and ephemeræ, which, when arrived at their mature condition, hover like clouds over swamps and marshy places. Even the water-butt, wherever water-butts are fashionable, contains the ubiquitous larvæ of the gnat. Standing waters are as much a necessity to the large family of gnats as to toads and frogs, as all those have experienced who have attempted to spend a few quiet summer nights in some of the fenny districts.

The female gnat deposits her eggs on the surface of the water, in which her offspring are destined to pass so much of the earlier portion of their career. These eggs are glued together at the moment when they are deposited by the mother, so as to form a mass resembling a little boat, so beautifully constructed as to float unharmed even during the roughest weather. The eggs of which this little bark is composed are conical in shape, and closed at one end by a kind of lid, by means of which the mature insect is destined to make its escape. The larva, as is well known, does not bear the slightest resemblance to the perfect insect, and its organs of respiration are singularly modified in accordance with its habits. The head is large and supplied with two feelers or organs, which, by their movements, bring food to the mouth. The thorax is larger than the head, and furnished with tufts of hair. At the end of the tail are certain fan-like fins, which, by their motion, help to sustain the larva at the top of the water, where it remains suspended, with the head downwards. In such a position respiration would be impossible but

for an arrangement of the breathing organs which allows of free communication with the air. The tracheæ, or breathing pores, are connected with a tube, appended to the last segment but one of the abdomen, the perforated end being raised above the water, so that the creature obtains from the air the oxygen necessary for respiration.

After casting its skin several times, the larva, being fully grown, enters the pupa state, and in this condition still remains aquatic, occupying a position near the surface of the water. In this altered condition it also changes its position, so that the back of the thorax, and not the tail, is brought into proximity to the surface.

"The problem to be solved," says Professor Rymer Jones, "is how shall the mature gnat escape from the water without being wetted? And when we consider that neither the larva nor the pupa possesses instruments of locomotion, capable of enabling it to leave its native element by crawling on shore, the difficulties attending the change appear almost insurmountable. It is evident that while swimming, in the position in which the larva floats, the last change could not by possibility be accomplished, as the bursting of the integument would at once admit the water to the submerged gnat, and drown it at the moment of its birth; but by the new arrangement the metamorphosis is easily effected, and that in a manner so beautiful, that it is hard to say which is most admirable, the simplicity of the contrivance, or the perfection with which the object is accomplished. No sooner has the encased imago become fitted for its escape than the pupa, rendered more buoyant, raises its back

above the surface; the protruded portion of the pupa-case soon dries, and gradually begins to split in a longitudinal direction, so as to form, by its expansion, a boat wherein the gnat swims upon the top of its native pond; and sustained in this frail bark, formed by its late skin, it gradually extricates its legs and wings from their coverings, and is kept perfectly dry until the expansion of its instruments of flight enables it to soar into the air, and quit for ever the raft so singularly provided for its use."[1]

Not many years ago, when the weather was unusually hot, there was a great cry, and some alarm, from Woolwich and other places on the Thames, that the mosquitoes had come. Of course there was discussion, and some affirmed that mosquitoes are only gnats, with the sting rendered more venomous by hot weather. Mosquitoes and gnats are but popular names for two-winged insects belonging to the same genus. What is called the "mosquito" in India or in North America, is only a gnat, but in each case of a different species to that which is most common in this country. Even here, we have not one species of gnat, but several, and the larvæ of all are aquatic. It requires the knowledge of an experienced naturalist to distinguish a Yankee mosquito from a British gnat by the appearance only. But no such scientific knowledge is requisite when it becomes a question of feeling rather than one of judgment.

There is one anecdote extant of how mosquitoes

[1] Prof. Rymer Jones's "Animal Kingdom," p. 396.

were once turned to good account in California. A rogue had stolen a bag of gold from a digger and hid it. Neither threats nor persuasions could induce him to reveal the place of its concealment. He was at last sentenced to a hundred lashes, and then informed that he would be let off with thirty, provided he would tell what he had done with the gold, but he refused. The thirty lashes were administered, but he was still as stubborn as a mule. He was then stripped naked, and tied to a tree. The mosquitoes, with their long daggers went at him, and in less than three hours he was covered with blood. Writhing and trembling from head to foot with exquisite torture he exclaimed, "Untie me, untie me, and I will tell where it is." "Tell first," was the reply. So he told where it might be found. Then some of the party with wisps kept off the still hungry mosquitoes, while others went where the culprit directed, and recovered the bag of gold. He was then untied, washed with cold water, and helped to his clothes, while he muttered, as if talking to himself, "I couldn't stand that anyhow!"[1]

Wherever we read, or hear, of mosquitoes or gnats, it is in proximity to water, rivers, swamps, or bogs. Of all the products of fresh water, these are about the most numerous and annoying. It is related, in Butler's "Lives of the Saints," that Saint Macarius was a confectioner of Alexandria, who spent many years of his life in the desert, in penance and contemplation. "Happening one day inadvertently to kill a gnat that was biting him in his cell, reflecting that he

[1] Rev. Walter Colton's "Three Years in California," p. 250.

had lost the opportunity of suffering that mortification, he hastened from the cell for the marshes of Scete, which abounds with great flies, whose stings pierce even wild boars. There he continued six months, exposed to those ravaging insects; and to such a degree was his whole body disfigured by them with sores and swellings, that when he returned he was only known by his voice."[1]

By far the most interesting feature associated with mosquitoes, is one which was very recently illustrated by Dr. Spencer Cobbold. There are several forms of disease, such as elephantiasis, leprosy, &c., which are fearful in their nature, and unfortunately prevalent in hot climates. In these diseases the blood of the human subject swarms with minute parasitic bodies, which, however, never reach the perfect, or fully mature condition, in that state. It has long been subject of research to discover the perfect form, and these researches have at length been successful. As the result of experiment, it has been shown that these bodies are periodic in the blood. They conceal themselves in the neighbouring tissues during the day, and do not appear in the blood until five or six o'clock in the evening, and from that time continue to increase in number for some hours, and then again diminish as midnight is approached. At this evening time the mosquitoes are most ferocious, and, sucking the blood of the infected man, draw from him large numbers of the parasites. Whatever may be the cause, they have been shown to suck from the body a much larger percentage of parasites than would exude at the

[1] Butler's "Lives of the Saints," p. 50

same hour from a mechanical puncture. We here see a curious instance, very suggestive, of certain parasites coming into the blood just at the hour when the mosquitoes would be most active in removing them, and that they perform this operation most successfully. Further than this, it has been demonstrated that the parasites themselves attain their perfect condition, as soon as they are absorbed into the body of the mosquito. It was at one time supposed that the disease was distributed from individual to individual through the intervention of the mosquito, but this has been shown to be an inaccurate assumption. The work which the mosquito performs is so far beneficial, that it reduces the number present in the blood of the diseased person, and that in their imperfect state, as found in the blood, the parasites do not possess the power of increasing their species.

The question naturally arises, what becomes of the perfect forms? What is the rest of their life-history? It seems to be this. The female mosquito, for it is only the female that is a blood-sucker, gorged with blood containing perfect forms, hastens to stagnant water, or quiet water, especially margins of large rivers, and there, in accordance with her natural instinct, deposits her eggs, and almost immediately dies. Her body falling in the water soon decays, and within that body the living germs of the progeny of parasites, the result of the perfected forms, become diffused through the water. Natives drink of this water, and with it the germs or young parasites. These parasites, entering the human stomach, soon find their way into the blood, to be in turn sucked

out by other mosquitoes, and thus the cycle is completed.

Although these minute aquatic larvæ are not inhabitants of the water in these more favoured lands, yet this narrative will not be without its interest and its lesson. It is well known that in many cases the larval condition of parasitic worms is passed, or partially so, in water. From this fact we may gather the salutary conclusion worthy of remembrance, that drinking unfiltered water without boiling, from exposed places, even from rivers, is an act worthy of strong condemnation.

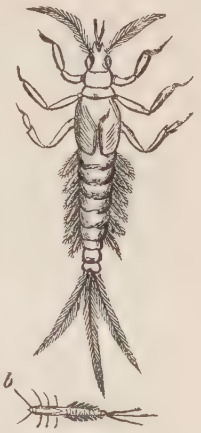
Clouds of minute insects, smaller than gnats, equally delicate, and still more rapidly passing away, are to be seen hovering in the air in damp marshy districts. These are the Ephemeridæ, or day-flies, to whom the name of Ephemera[1] has been given, on account of the short duration of their lives. Some of them, in their mature condition, never see the sun. They undergo the final change into the winged stage after the sun has set, and die before it reappears on the horizon.

It has been stated that on the banks of some of the rivers in France these flies appear in such numbers that the fishermen on those waters have a current belief that they are showered down from heaven, and accordingly call the living cloud manna. Reaumur, the distinguished naturalist, has stated that he once saw them descend so fast that the step on which he stood by the river's bank was covered by

[1] The *antennæ* in our figure are exaggerated.

them, in a layer four inches in thickness, in a few minutes. He compares their falling to that of snow, with the largest flakes.[1] Scopoli also writes of similar swarms in Carniolia at certain seasons of the year. And these also are "children of the waters."

Kirby and Spence[2] enumerate a long list of genera of insects, the larval condition of which is passed in the water. "Some walk on the ground under water; some move in mid-water, either by the same motion of the legs as they use in walking, or by strokes as in swimming; others for this purpose employ certain laminæ, which terminate their tails as oars; others, again, swim like fish, with an equable motion; some move by the force of the water which they spirt from their extremities, others, again, swim about in cases, or crowd over the submerged bottom; and others walk even on the surface of the water."




LARVA OF EPHEMERA.
*b* Natural size.

We have nearly fifty different species of dragon-flies, and their larval conditions are passed in the water. Here are then many aquatic animals whose history may be studied, until they emerge from

[1] Reaumur's "Memoirs," vol. vi. p. 485.
[2] "Introduction" (1858), p. 442.

their watery element and disport themselves in the air. Eleven months of the life of a dragon-fly are spent in the water, and only one on wings, making up the natural term of its existence. These larvæ are very active, being provided with six legs, which they employ to the best advantage. The large head is ornamented with enormous eyes, which serve to impart a terrific appearance, and its ever-hungry jaws are concealed by a mask. "Not only does the immature Dragon-fly walk over the bottom of the pool or stream it inhabits, but it can also leap for a considerable distance by a most curious contrivance. By a syringe-like apparatus lodged in the end of its body, it discharges a stream of water for a distance of two or three inches behind it, thus propelling the insect forwards. This apparatus combines the functions of locomotion and respiration. There are, as usual, two breathing pores on each side of the thorax; but the process of breathing seems to be mostly carried on in the tail." From the larva, this insect passes into the pupa stage, also in the water. It is still active, and as voracious as ever. "When the insect is about to assume the pupa state, it moults its skin, the body having outgrown the larva-skin; by a strong muscular effort a rent opens along the back of the thorax, and the insect, having fastened its claws

LARVA OF DRAGON-FLY.

into some object at the bottom of the pool, the pupa gradually works its way out of the larva-skin. It is

HAUNT OF THE DRAGON-FLY.

now considerably larger than before. Immediately after this operation its body is soft, but the crust soon

hardens." At length, when the time for its final change arrives, the pupa climbs up some plant near the surface of the water. Slowly and gradually as its prison-case splits open, the winged insect escapes, and after resting awhile to dry and harden its flabby wings, it starts on its last career of insecticide—

> "To-day I saw the dragon-fly,
> Come from the wells where he did lie.
> An inner impulse rent the veil
> Of his old husk : from head to tail
> Came out clear plates of sapphire mail.
> He dried his wings ; like gauze they grew ;
> Through crofts and pastures wet with dew
> A living flash of light he flew."

Any one who observes the rapid flight of the dragon-fly, and indeed the majority of insects, must be impressed at once with the enormous rate of speed in proportion to size which they attain. Leeuwenhoek narrates an instance, in which he was an eye-witness, of the capabilities of the dragon-fly and the swallow in rapidity of flight. The bird and the insect were both confined in a menagerie about 100 feet long, and apparently their powers were fairly tested. The swallow was in full pursuit, but the little insect flew with such astonishing velocity that even this bird of rapid flight and ready evolution was unable to overtake and entrap it ; the insect eluding every attempt, and being generally six feet before it. "Indeed," write Kirby and Spence, "such is the power of the long wings by which the dragon-flies are distinguished, and such the force of the muscles which move them, that they seem never to be wearied with flying. I have observed one of them sailing for hours over a piece of water, some-

times to and fro, and sometimes wheeling from side to side, and all the while chasing, capturing, and devouring the voracious insects that came athwart its course, or driving away its competitors—without ever seeming tired or inclined to alight."[1]

An anonymous writer in "Nicholson's Journal" calculates that in its ordinary flight the common house-fly makes with its wings about 600 strokes, which carry it five feet every second; but if alarmed, he states that their velocity can be increased six or sevenfold, or to 30 or 35 feet in the same period. In this space of time a racehorse could only clear 90 feet, which is at the rate of more than a mile in a minute. Our little fly, in her swiftest flight, will in the same space of time go more than the third of a mile. Now, compare the infinite difference of the size of the two animals, ten millions of the fly would hardly counterpoise one racer, and how wonderful will the velocity of this minute creature appear! Did the fly equal the racehorse in size, and retain its present powers in the ratio of its magnitude, it would traverse the globe with the rapidity of lightning.

It is curious to speculate upon the result of dispensing with this balance of power, by which Nature restricts the dimensions of an insect within certain bounds, even in the case of a single species. Let us suppose the wasp or the stagbeetle, as has been suggested, expanded in bulk to an equality with the tiger or the elephant, enclosed in an impenetrable armour, furnished with jaws capable of crushing the solid trunk of an oak, and, withal, possessing enor-

[1] Kirby and Spence, "Entomology," p. 35.

mous powers of flight, from which escape would be hopeless, what could possibly resist the ravages of such destroyers, or how could the world support their ravages? But, fortunately, each creature is organised and accoutred for the position it is intended to occupy, and harmonized with its surroundings, so that a limit is fixed to its capacity for mischief. We may indulge in comparisons like these, in order to appreciate the wonderful powers of which they are the possessors, but, at the same time, such speculations can only serve to strengthen the impression of the unity and harmony of a world controlled by a supreme and all-wise Intelligence.

It cannot be supposed that any one who wanders by the margins of streams, lakes, or ponds, will pursue such an avocation long without becoming cognisant of certain cylindrical cases, fabricated of all kinds of

CADDIS CASES.

trifles, agglutinated together into a habitation for what are called "Caddis-worms." These cases are most interesting examples of insect homes, as wonderful and instructive as birds' nests, and as variable in appearance. Caddis-flies are little, unobtrusive insects,

with four membranous wings, and little that is attractive about them. We have many species, and all, with one or two exceptions, have aquatic larvæ, and these latter construct for their residence the tubes called caddis-cases. One common form consists of a cylindrical tube, of equal diameter throughout, formed of fragments of leaves and other vegetable substances, neatly arranged in a spiral manner, with the spiral turned from left to right, or from right to left.[1] The inhabitants of these cases have the power of turning themselves, so that their heads may be thrust out at either end. Other cases are fabricated of shells, seeds, pieces of wood, and rushes arranged in various order, so as to give great variety to their general appearance, more or less beautiful, according to the materials available to the little architect. Sometimes such materials have been artificially supplied in order to test the building instincts of the little larvæ, and the result has been the construction of most ornamental cases. A tolerably common case is made from pieces of moss, cut into convenient lengths,[2] but an equally abundant form of case is that in which the insect by no means confines itself to vegetable fragments, but uses all such objects

CADDIS CASE.

CADDIS CASES.

[1] *Phryganea grandis* and other species.

[2] *Limnephilus rhombicus.*

as we have indicated above, or indeed almost any substance, without the slightest semblance of order or selection.[1] "A conchologist might frequently examine these cases with profit, for a good miscellaneous shell-case will give a better idea of what fresh-water molluscs may inhabit any particular spot than probably would many hours of dredging and searching. It matters little whether the shells be empty, or still contain their proper inmates, these latter must submit to be dragged about at the will of the creature that has thus unceremoniously pressed them into its service; and if they do not die in that position, they must patiently await the time when, after the escape of the perfect insect, the binding materials of the case may rot, and set free the various matters composing it."[2]

CADDIS CASE.

Other cases are formed of sand, either wholly or with long twigs attached to the outside. Small sand cases, round and quadrangular, straight or curved, cylindrical or tapering, according as they are the work of different species, will commonly be found in ponds, especially one of a larger kind, with the upper surface projecting at one end in such a manner that it serves as a cover and protection to the insect when it protrudes its head from the case in search of food. The knowledge of the existence of these little case-makers is by no means of recent date. Hear what Aristotle

[1] *Limnephilus flavicornis.*

[2] R. M'Lachlan in "Science-Gossip," 1868.

has written about them, long before microscopes or naturalist's clubs were thought of:—"There is a small, worm-like creature, called Xylophthorus; its variegated head extends beyond its case, its feet are at the upper extremity, as in other worms; the rest of the body is contained in a case made of a substance like a spider's web, around and outside of which are chips of wood, so that the animal walks about with this attached to it. These creatures are attached to their cases as an oyster to its shell; the whole of the case is joined to the worm, and does not fall out of it, but can be drawn out as if they grew together. If any one pulls off the case, the animal dies, and becomes as helpless as a snail without its shell. As time advances, this worm becomes a chrysalis like a caterpillar, and lies without motion; but the nature of the winged creature that is produced from it has not been ascertained."

CADDIS CASES.

The very numerous order of Beetles is one of particularly terrestrial habits, yet there are amongst them several genera in which either the larva or the perfect insect, or both, are aquatic. The most familiar example of this is the Great Water-beetle,[1] a

WATER-BEETLE.

[1] *Dytiscus marginalis.*

very "ogre" amongst the unprotected of pond insects.

Of all the ferocious creatures which disport themselves in the waters, commend us to the larvæ of the Great Water-beetle. "Once I kept one in a basin of water," says Mr. McIntyre, "for a fortnight, during which time he ate seven or eight tadpoles, besides sundry earthworms, and grew so large that he cast his skin twice. If a small stick were presented to him, he would grasp the end boldly; that mode of testing his bravery being deemed more prudent than offering him a finger, which, judging by his manner of despatching tadpoles, might have been painfully made acquainted with the sharp points of his mandibles. One gripe was sufficient to settle any tadpole, and was always taken through the sides, apparently quite transfixing the poor little wretch, which quivered while life lasted, its enemy meanwhile keeping tight hold, and sucking its juices till nothing but the blanched skin was left to tell the tale. Earthworms were more trouble to him, since, owing to their violent struggles, he was obliged to divide the larger ones and eat them piecemeal."

LARVA OF WATER-BEETLE.

The mature insect, which is also aquatic, is no less terrible. Those who make the mistake of introducing these large beetles into their aquaria, for the sake of

their activity and imposing appearance, soon discover what a mistake they have made, by the gradual disappearance of all the smaller insects and animals. If they are favoured with an aquarium at all, it should be one in which there is nothing for them to harm, and the top should be so covered that they cannot make a moonlight escapade.

The Whirligig Beetle [1] is a much more respectable member of insect society, conducting itself in a lively but much less ferocious and bloodthirsty manner.

Of all aquatic insects, none surpass in interest those belonging to the true *Hemiptera*, or, as usually termed, "the bugs." Not that there is much external resemblance between these aquatic members of the family and their metropolitan representatives, but the latter is a strictly urban application of the name. In the United States the name "bug" has a very wide application, since it is often applied to beetles, but its intermediate restriction to those insects which are known to entomologists as true *Hemiptera* is the most reasonable. The aquatic bugs which are most familiar are the *Nepa* and the *Notonecta*: the "boatman" and the "water scorpion." Such of these insects as possess wings, have always four, of which the outer or upper pair are firm and leathery in texture in the basal half, and membranaceous in the outer half. The two we have named, especially the "water-boatman," are very common in stagnant waters, both in the larval and mature condition. The largest and most imposing of these insects is

[1] *Gyrinus natator.*

one which has also been called the "water-scorpion," but a very different insect from the *Notonecta*. On account of this confusion of names, it will be necessary to refer to the large water scorpion by its other name of *Ranatra*.[1] It has a long abdomen, of a vermilion red colour, terminating in two long setæ, which are as long as the abdomen. This creature inhabits the water in every stage of its existence. The perfect insects leave the ponds and ditches they inhabit in the evening, and may be found on the mud at their margins. Like most other winged water-insects, they fly in the night, sometimes to a considerable distance, in search of a better home, should their own pools be nearly dried up. This is rather a ferocious carnivorous insect, living upon other insects, which it holds between its fore feet, whilst it pierces and sucks them with its beak or rostrum.

The aquatic family of bugs which are called *Hydrometra*, live on the surface of running or stagnant water, where they propel themselves rapidly by the rowing motion of their second and third pairs of legs; feeding upon any insects that may come in their way, catching them by springing upon them; with a capacity for diving when alarmed. There are several species of *Hydrometra*, but we are not aware that they are sufficiently popular to have acquired a vulgar name. They attain from four to seven lines in length; and at least three species are common on stagnant water, whilst a fourth is attached to running streams, up which it runs with celerity against the current.

[1] *Ranatra linearis.*

The *Velia*,[1] another of the same kindred, is common on clear streams, smaller in size, but gregarious in habits, living in company on the surface of the water, and not unlike in appearance to little spiders. They move rapidly by a succession of leaps.

We might also note at least eighteen different species of *Corixa*, some of which are confined to brackish water, such as the ditches near Gravesend, but others are found on inland pools, and other stagnant waters. Not less than three kinds are decidedly common, and one [2] has the reputation of being very common. These by no means exhaust the list of "water-bugs," even of the most common. There is a little fellow, fond of creeping about slowly on the water amongst duckweed, and whose portrait was drawn by Curtis, more than half-a-century ago.[3] Another, as rapid in motion as the latter is sluggish, swims by means of its four hind legs.[4] This will suffice to give some idea of the nature and habits of an obscure, and but little-known, group of insects with a special fondness for ponds and ditches. It is affirmed that the insect eggs which are collected as food by the Mexicans, are those of some kind of water-boatmen. These eggs are collected from the lakes and made into a kind of cakes called "hautle," or more probably by some Mexican name of which this is a corruption. "On the lake of Texcoco," writes one Brantz Mayer, of Mexico, in 1844, "I saw men occupied in collecting the eggs of flies from the surface of plants and cloths arranged in long rows

[1] *Velia currens.*
[2] *Corixa sahlbergi.*
[3] *Limnobates stagnorum.*
[4] *Naucoris cimicoides.*

as places of resort for the insects. These eggs formed a favourite food of the Indians long before the conquest, and when made into cakes resemble the roe of fish (caviare), having a similar taste and appearance. After the use of frogs in France, and birds' nests in China, I think these eggs may be considered a delicacy, and I found that they are not rejected from the tables of the fashionable inhabitants of the capital." The eggs of three kinds of insects have been identified as forming this delicacy, two of which are species of *Corixa*, of which we just stated that eighteen kinds are inhabitants of Britain, and the other insect is a kind of *Notonecta*.

Thus rapidly have we executed our pond-hunting excursions, and, at its close, find the subject not only unexhausted, but even with more unwritten than we could have wished, and only the slightest glimpse afforded of the multitudinous life of still waters. Roaming over such a wide field as the whole of the vegetable and animal life of fresh waters, it could hardly be anticipated that these little books could be rendered sufficiently rich in detail to serve as text-books; all they can claim for themselves is to serve as introductions to studies for which text-books will be as essential as ever. One cannot contemplate an open page of the book of Nature, like the present—one, perhaps, but little scanned, seldom read, or pondered over—without being deeply impressed with the prodigality with which the wonders of an all-powerful and all-wise Creator are scattered to the furthest limit of a wonderful world. The same order, the same fitness, the same completeness which characterises all the visible universe, is

again represented in that part which is so minute in all its details as to be invisible to the naked eye. "Of all the blessings which the study of nature brings to the patient observer, let none, perhaps, be classed higher than this; that the further he enters into those fairy gardens of life and birth, the more he learns the awful and yet most comfortable truth, that they do not belong to him, but to One greater, wiser, lovelier than he; and as he stands, silent with awe, amid the pomp of Nature's everbusy rest, hears, as of old, 'the Word of the Lord God walking among the trees of the garden in the cool of the day.'[1]

[1] Kingsley's "Glaucus."

## CHAPTER XV.

### ON COLLECTING AND EXAMINING.

A VOLUME of this character could hardly be considered complete if it did not furnish some hints to the novice for the prosecution of "rambles," such as the preceding pages assume. In many other rambles little advice is needed, since the objects are large, or at least visible without searching, fish and other aquatic animals excepted. On the other hand, we have professed to deal largely with the *invisible*, not so much so on account of their size, but chiefly because of their aquatic habits. In this sense our objects are on an equality with the fish just referred to, they are hidden in the waters, and must be brought to the light of day before they can afford either amusement or instruction. Hence some advice from one who has often hunted in ponds will be a necessary and welcome close for the volume.

On this subject, as most other out-door pursuits, everyone has his own "crotchet," and hence different methods are in vogue for the attainment of the same object, some persons preferring the one, and some another. Where such different methods seem to merit notice, we need not apologize for a plurality of modes. During the progress of the work we have already dropped a hint or two by the way, applicable

to the subject then under consideration. Plain matter-of-fact suggestions are hardly essential, yet we cannot forbear, at the outset, reminding our readers that pond-hunting is not drawing-room work. If we would be successful, we must enter upon this, as upon all other work, with zeal and resolution. In order to do this without injury to health, proper preparation should be made. To go abroad, and wander over the low swampy parts of a heath, a boggy moor, or beside marshy ditches, the first necessity is to have the feet well protected and encased in sound boots, though they may not be handsome. Standing about, it may be for hours, in oozing, penetrating swamps, will prove dangerous work unless this precaution be taken. Some ponds and some ditches may, like canals, have a sound, hard road beside them, but this is the exception rather than the rule. Yet no one need to have wet feet because they choose to study that phase of life which is manifested in ponds and ditches.

Preparation must also be made for conveying home the spoils of the chase for subsequent examination. In collecting land-plants a botanical vasculum is all that is requisite, but this would afford poor accommodation for aquatic objects. The majority of these should be kept in water, and hence some arrangement of bottles is essential. Pill-boxes may do very well for the snails, and even the beetles, but for little else. A good supply of wide-mouthed bottles, fitted with corks, is indispensable. They may go into all the pockets, or cases may be purchased at some of the opticians, fitted with bottles, and adapted for the

work. We will not pretend to say which is the cheapest or the best.

In addition to the bottles, some persons recommend oil paper, waxed cloth, or gutta percha tissue for wrapping the larger plants, filamentous Algæ, and such objects; or a small vasculum may be applied to this purpose, if preferred. Many more hints than we can give are contained in Nave's "Handy Book to the Collection of Algæ and other Objects," translated from the German. Provided in this manner for securing the spoil, the next consideration is, how to obtain it. Most of the things which one is likely to see will be out of reach of the hand. Some of these may be reached with a walking-stick, furnished with a hook at one end; others, still further off, will have to be brought to the shore by some other contrivance. A triple iron hook, such as we have figured, attached to a cord and thrown over the bed of weeds, in which it will sink by its own weight, and then drawn gently to the shore, is one method. Others recommend a kind of rake, or a longer stick—let each be persuaded in his own mind.

COLLECTING HOOK OR "DRAG."

There will be minor objects out of reach, for which the hooks are useless, and some means of dipping in a wide-mouthed bottle will be necessary. The original plan was to attach a wide-mouthed bottle with

a spreading lip, by means of an elastic band, to the end of a walking-stick; since that time a brass ring has been devised which fits round the neck of the bottle like a collar, and may then be screwed into the end of the stick. This plan secures greater firmness, and is to be preferred. When a dip with the bottle has been made, it may be held up to the light to see what it contains, and probably some objects will be so minute that the naked eye will be insufficient to give satisfaction. In that case a pocket-lens, of an inch focus, or a combination of two or three lenses, will be essential. No one should dream of going out on an excursion in search of objects of natural history without a pocket-lens and a pocket-knife. Without these essentials he had better stay at home, for only vexation and disappointment will be in store for him.

Taking for granted that the bottle contains a good dip, some of the water may be poured off carefully, and the residue transferred to another bottle, corked and pocketed, and another dip taken. If plants or animals of a visible size are the objects of search, a piece of muslin or linen in the pocket will not occupy much room, and be used as a strainer, and less water will have to be carried away. For minute objects, some will prefer a small japanned case fitted with corked tubes, six or eight, and not too large for the breast pocket. Beyond these hints experience will be the best guide, and necessity will become the mother of invention.

Arrived home again with the results of the day's excursion, the bottles must be all uncorked to allow of access to the air, then the contents may be trans-

ferred to tumblers, or other larger vessels, rain, or pipe-water added, and the stores put on one side, in a light and cool place until next day, or they may be examined at once, according to convenience. It may be that already a small fresh-water aquarium has been extemporized, and into this all the contents of the bottles may probably be transferred. This will be determined by the objects and desires of the collector. Should the object be merely to get together a number of illustrations of pond life, regardless of whether they eat each other or not, they may be mixed; but if other and higher aims prevail, each bottle will first be examined to see what it contains, and disposed of in a more systematic manner.

The examination of the minutest objects cannot be attained without the use of the microscope. Anyone in possession of such an instrument will need no instruction from us how to use it; anyone *not* in such happy possession would skip those instructions if we were to give them; therefore, either way, the labour would be lost. This assumes that the few lines which we could devote to introductory hints as to the use of the microscope would scarcely serve the purpose of one who has everything to learn, and not be requisite for one who has already learnt by experience. There is a great deal to be learnt as to the best methods of employing a microscope, but so many useful books have been written specially on this subject that we may pass it over here.

Anyone who has had sufficient interest in the subject to accompany us as far as this last chapter, is on a sure road to obtain a microscope for him or herself,

if not the possessor already. If the idea has never presented itself to the mind in such a definite shape, let us suggest it. The use of this marvellous instrument is not only the addition of new eyes, but an introduction to a new world, in which the appearance of its inhabitants is wholly different from those of the visible world. If only as an amusement, it is the most wonderful toy that was ever invented, and it has the advantage over all other toys that its variety is practically unlimited. The manipulation is simple and soon acquired, and the cost is so minimised that it is no longer an obstacle. Depend upon it that, even if employed only as an amusement, instruction will come unawares.

"What better encouragement and direction can possibly be given to the exercise of the *observing* powers of a child than to habituate him to the employment of this instrument upon the objects which immediately surround him, and then to teach him to search out novelties among those less immediately accessible? The more we limit the natural exercise of those powers, by the use of the methods of education which are generally considered to be specially advantageous for the development of the intellect, the more we take him from fields and woods, from hills and moors, from river-side and sea-shore, and shut him up in close school-rooms and narrow playgrounds, limiting his attention to abstractions, and cutting him off, even in his hours of sport, from those sights and sounds of Nature which seem to be the appointed food of the youthful spirit, the more does it seem important that he should in some way be

brought into contact with her; that he should have his thoughts sometimes turned from the pages of books to those of creation, from the teachings of man to those of God." And again, the same author writes —"A single rural or even suburban walk, will afford stores of pleasurable occupation for weeks in the examination of its collected treasures. A large glass jar may be easily made to teem with life, in almost as many and varied forms as could be found by the unaided eye in long and toilsome voyages over the wide ocean; and a never-ending source of amusement is afforded by the observation of their growth, their changes, their movements, their habits. The school-boy thus trained looks forward to the holiday which shall enable him to search afresh in some favourite pool, or to explore the wonders of some stagnant basin, with as much zest as the keenest sportsman longs for a day's shooting on the moors, or a day's fishing in the best trout-stream; and with this great advantage over him, that his excursion is only the beginning of a fresh stock of enjoyment, instead of being in itself the whole."[1]

As an illustration of these remarks we may detail a small item of experience. One Saturday afternoon in February, the weather being still cold and rather uninviting, we spent a single hour on Hampstead Heath in filling two or three small bottles from the standing pools in the lower parts of the heath. There was not much to excite attention, a little green thready scum on some of the pools, and some float-

[1] Carpenter, "On the Microscope," p. 28.

ing *débris* of vegetable matter on others, the latter coated with a dirty-looking brownish film. A few dips from some of the pools could be seen to contain a few active Cyclops. Nevertheless, we took home, in all, about two ounces of water, containing Conferva and some dirty scum, with a few Cyclops, and a little of the small duckweed floating on the top. This collection we transferred at once to a common tumbler, with a little additional water, and thus extemporized an aquarium. Most of the confervæ and *débris* settled at the bottom. The duckweed covered the surface. Cyclops floated in the region intermediate in free and undisturbed vivacity.

A month passed after this excursion, and before these lines were written ; the water remained as clear and fresh as at the first, and the Cyclops as healthy and vigorous. On the surface the duckweed was still green and growing. But, during that month, this tumbler of pond-life gave full occupation for all our leisure. We needed no fresh excursion, for the results of the first were not exhausted, and yet it was made at one of the most unfavourable seasons of the year. The Cyclops consisted of two species, one of them with the antennæ consisting of seventeen joints,[1] and the other of only twelve.[2] The former were twice as large as the latter. Some females were bearing their pouches of eggs. One large female was also almost covered with a parasitic Vorticella or bell-animalcule. The bells, at the

[1] *Cyclops tenuicornis.* [2] *Cyclops serrulatus.*

end of long retractile stems, jerked up and down catching their prey. Amongst the *débris* at the bottom of the glass we found also another bell-animalcule, attached to old Conferva, the bells much smaller, and the mouth less expanded.[1]

Crawling amongst the *débris* were numerous water-bears, large and small, and these furnished amusement for an entire evening with the microscope. We had sometimes four specimens at the same time upon the slide, creeping about and exhibiting their claws in vain attempts to hold upon the slippery glass. Mixed with the same material, on subsequent occasions, no less than three kinds of Rotifers or wheel-bearers were found; the large common rotifer, and two free-swimming smaller active species. It was amusing to see the large rotifer creeping about after the mode of those caterpillars which are termed loopers. Stretching out and holding on by the proboscis, then drawing up the foot nearly to the head, fixing it, and then advancing the proboscis as before, and thus migrating from place to place. Nearly every examination from this store afforded some new object. The tumbler of pond-life seemed to be inexhaustible. There were Diatoms, and one solitary species of Desmid, green Algæ, both unicellular and filamentous; Infusoria of various kinds, from the large Stentor down to the minute "Ptyxidium." Some were undergoing division, and what was previously only one individual was gradually becoming two. Even lower still in the grade of existence were two

[1] *Vorticella microstoma.*

kinds of Proteus or Amœba,[1] and the Sun-animalcule or Actinophrys, not one or two individuals only, but by scores. Then there were the very interesting creatures called Euglena, and of these no less than three different kinds; one, common everywhere, spindle-shaped and active,[2] another larger, but more sluggish, and only seen singly,[3] and finally a small disk-shaped flat species,[4] wavering about like a tiny green leaf, and all exhibiting their bright red eye-spot. But it would become tedious were we merely to enumerate all that we found successively in this little tumbler of water; it must suffice to say that we do not regard it as exhausted, but whenever an opportunity permits we take a bit of the sediment from the bottom, place it upon a slip of glass, add a drop of water, cover it with a covering-glass, and then examine it with a quarter-inch objective.

If one short ramble, of only an hour's duration, at a most unpromising season of the year, could give us continued occupation for all our leisure during an entire month, it must be presumed that later, and at a more congenial season, the results of an excursion would be almost inexhaustible. It is not the mere determination of the names of an indefinite number of objects that is desirable. This is by no means a primary advantage, unequal to the interest and importance of watching and tracing the varied changes, stages of development, and method of life in minute

[1] *Amœba limax* and *Amœba guttula*.
[2] *Euglena spirogyra*.
[3] *Euglena viridis*.
[4] *Euglena pleuronectes*.

organized beings such as these, which on account of their small size have been but little studied, and the life-history of which is comparatively unknown. That mode of increase which results from budding or division, is not represented in the larger animals which come under the cognizance of the unaided eye, but these are methods common amongst such microscopical creatures as those which abound in our ponds and ditches.

Cells have been devised specially for the examination of this class of objects, the main principle of which is to maintain a supply of water which can be kept up day after day, whilst the thickness of the cell is reduced as much as possible, so as to bring it within the limits of the higher powers of the microscope. The thinnest form of cell is a kind of growing cell, one end of the slide being dipped in water, so that it is kept filled by capillary attraction, when not under examination. Very small Infusoria would, however, flow out as easily as the water flows in, so that after all much will have to depend upon the ingenuity of the operator, to adapt the various contrivances to his own individual circumstances.

The preservation of most of the aquatic objects to which we have directed attention cannot be said to be satisfactory. There are very few of the animal objects which will suffer mounting as permanent preparations. Considerable improvements in mounting have taken place of late years, but these can never equal the living animal with its organs in action ; and no wheel-bearer, mounted in ever so perfect a manner, can compete with a living wheel-bearer under the

microscope, with its circlets of cilia in rapid movement and the masticatory organs in operation.

The filamentous Algæ, or Confervæ, can be floated in a plate or shallow dish, slips of paper passed under them, and then lifted gently out of the water in such a manner that the Algæ become deposited on the paper, just as they floated in the water. In this manner many, if not all, of the thread-like water-weeds may be dried and preserved for future reference, and these will generally adhere to the paper with all requisite tenacity.

The unicellular Algæ are not so easily preserved, except as microscopical preparations, and these deteriorate by the derangement of the endochrome and change of colour. The beautiful green of the Desmids vanishes in the course of a short period, and the empty fronds exhibit an ill-defined outline through excessive transparency. Diatoms, of course, are the great exception to this rule. The siliceous frustules are practically indestructible, and will remain almost for ever without change. This is one feature which has contributed to the popularity of the study of the Diatomaceæ, a popularity which has never been equalled by the other unicellular Algæ.

The difficulty still remains unsolved as to the best manner of preserving specimens of Desmids, and such like small Algæ, for future reference. Some have adopted the primitive method of drying them like a green stain on paper, which is very unsatisfactory. Others have spread them in a thin film on strips of glass and allowed them to dry; but glass is easily broken, and the drying will shrivel the specimens

so that moisture cannot recover them. This latter difficulty belongs to every method. The best mode known to us is to spread the minute Algæ on small strips or squares of thin mica; by moisture applied to these, for a period sufficiently long, much of the original form will be recovered, and detail enough to discriminate between species.

But, as to the minute animals, the transparent Infusoria, the delicate Polyzoa, the water-bears, mites, and many others, what can be said? We fear that all we can recommend is that they should be studied as much and as often as possible in the living state. The pencil should be freely employed in sketching them in all the positions they assume, and in portraying all their changes, and every detail of their structure. Hereafter, we doubt not, considerable improvement, implying great advancement in the art of mounting objects for the microscope, will overcome many of the difficulties. Staining tissues already has done a great deal, and possibly stained Infusoria will not be amongst the impossibilities of a future.

Whilst examining the wheel-bearers and ciliated Infusoria under the microscope, it will often be found advisable to devise some method whereby the form of the stomach and viscera, or of the movement of the cilia, may be determined. It is usual to do this by dissolving indigo, or some other colouring matter, in the water. This will enable one to trace the current into the bodies of the animals themselves, and the vortex caused by the vibration of the minute cilia will be more distinctly seen. In the case of the bell-animal-

cule, in which there is a very strong rotary current, in comparison to the size of the animal, this method will greatly enhance the beauty and interest of the object. It is a kind of temporary staining for which, by-the-by, the aniline colours are not available, as they are too diffusive, and, moreover, soon kill the animals.

The activity of some of the animals is a great obstacle to their close examination. It has been recommended to thicken the fluid by means of some such an addition as gum-water, so as to limit this motion, but we fear this would not be a very successful method. There is an article of apparatus which accompanies the microscope, called a compressorium, which is of more practical use. It is a kind of box in which the object is compressed between two plates of glass, and in the most improved form of compressorium the amount of compression may be regulated in a definite manner, so as to avoid the catastrophe of compressing to the point of rupture. It will hardly be possible to examine such erratic objects as water-fleas and cyclops without some such method is resorted to. With an active cyclops twisting up and down, and jerking in all directions, it would be impossible to count the joints in the antennæ, until by some means an effectual check is put upon its skipping propensity. It is quite possible to dissolve out the contents of these creatures when dead, and thus secure good permanent preparations.

Finally, what method is best to be adopted for obtaining the largest amount of instruction as well as of satisfactory recreation from the study of pond

life? It is, and always has been, a favourite crotchet with us to recommend strongly *concentration*. To concentrate the attention and interest as much as possible to certain definite objects, or class of objects, and not attempt to know or understand everything at once. We have seen in times past how the persistent application of one person to the study of a single insect has been productive of the most marvellous results. We would advise any one in search of recreative occupation to make a careful selection of the kind of objects most available, or having the greatest attraction. Thereafter, let it be the first object of such an one to study and examine, and exhaust, if possible, the history of such an animal or group of animals, or plants. Whether the selection be in favour of Desmids, or Infusoria, or Water-fleas, or Wheel-bearers, it matters not, but, unless the area is so circumscribed, no sound knowledge can be obtained—nothing but an empirical acquaintance with a lot of hard names. When once a selection is made, a series of experiences will commence, as to their homes and haunts, how they are best obtained, perhaps how they are to be domesticated or cultivated; and then will follow a series of observations upon their habits, modes of life, foes and friends, food, and methods of increase, and light will begin to dawn upon some of their uses as links in the great chain by which Nature is united to nature's God. It is by such method in study, and by method only, that study will bring its reward in the satisfaction of having spent so many hours in recreation not wholly in vain.

We might quote from Bacon, and, indeed, from authors innumerable, on the advantages which result from method in studies of whatever kind, but this is needless, since it is universally admitted that all useful study is methodic. The course which we have suggested has also the advantage of circumscribing the amount of reading necessary to epitomise all the known facts, and keep the worker abreast of the discoveries of the age. This assumes that it is intended to acquire complete mastery of the subject selected; and is this not also a commendable purpose? It is a good principle to propose to one's self a high aim, even should it never be attained. Perfectly satisfied that only a very few would make any effort to realise such a student as we have indicated, it is nevertheless our duty to speak that which is on our mind. And now, whether skimming on the surface, or delving deeper in order to comprehend the mysteries of minute life, we leave our whilom companion to wander and ponder in search of truth, and think on Him to whom

> "All acts are equal; for no more
> It costs Omnipotence to build a world,
> And set a sun amidst the firmament,
> Than mould a dew-drop, and light up its gem."

---

NOTE ON PRESERVING, ETC.—For some years we were accustomed to mount Desmids and other fresh-water Algæ, for the microscope, in fluids (usually simple water), and the method appeared to be successful, until tested by a longer period of time. After ten or twelve years scarcely a 'slide' remains in which the fluid has not evaporated, and the preparations have become

useless. Several kinds of cement had been employed, but, notwithstanding that to all appearance the cement was perfectly sound and impervious, the fluid had evaporated through it. This is still the difficulty which manipulators are endeavouring to overcome, to discover a cement which shall remain absolutely impervious, for an indefinite period. Having lost in this manner some thousands of preparations, and the labour of mounting them, we are led to utter this note of warning.

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